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Point-Model Dependent Sampling for Timber Inventory

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John C. Rennie

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Point-Model Dependent Sampling for Timber Inventory

John C. Rennie

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Introduction

This report describes how to plan and execute a timber inventory using point-model dependent (PMD) sampling. PMD sampling was developed for timber inventory by Schreuder (1981, 1984) to overcome problems in point-Poisson (point-3P) sampling. Wood and Schreuder (1986) developed detailed office and field procedures to allow easy use of PMD sampling by foresters. PMD sampling was extended to produce stand and stock tables during the development of PTMODEL, a computer program to process data from PMD inventories (Rennie 1987).

PMD sampling is a two-stage sampling scheme that involves two groups of trees. The first group comprises trees selected with a prism or angle gauge; only a small amount of data is collected on each tree. These "first-stage trees" are used to estimate the number of trees in the population and its mean D^2H (D is diameter breast height and H is height). The second group of trees consists of those selected for detailed measurement and subsequent calculation of regression coefficients for predicting volume, biomass, and board foot content. These "second-stage trees" are spread over the range of D^2H in the population being inventoried. The same trees may be, and probably will be, sampled in both stages.

Two BASIC programs used in designing an inventory with PMD sampling are presented. The program PTM_SIZE.BAS calculates combinations of number of sample points and number of second-stage trees that should achieve the desired precision. PTM_LIST.BAS produces D^2H interval lists for selecting the second-stage trees for detailed measurement. A mainframe program, PTMODEL, for processing data from PMD sampling is described. A case study is developed throughout the report to illustrate various steps of planning and execution with real world data.

Steps of the Inventory

The steps of the inventory described here include: preparation, execution, and processing. Preparation will include setting goals, defining merchantability standards and strata, conducting a preliminary inventory, calculating sample sizes, and assembling equipment and forms for the main inventory. Execution will consist of those activities related to collecting the data on the main inventory: establishing the sample points, and selecting and measuring the first-stage and second-stage trees. Processing will involve entering the data into a computer and running the data to obtain the necessary reports.

Case Study

The purpose of this case study is to demonstrate how to plan, execute, and process a PMD inventory. The inventory was simulated by selecting the samples from a large, existing data set rather than collecting new data. This procedure was adopted since it was less costly than an actual inventory.

The data are from a point-3P (point-Poisson) inventory on Prentice Cooper State Forest, Tennessee; this is a 25,537-acre tract west of Chattanooga managed by the Tennessee Division of Forestry. It is mostly hardwoods. There were 73 sample points, on which 694 first-stage trees were selected with a BAF 10 prism. One hundred thirty trees were measured in detail with a Barr and Stroud dendrometer.

Preparation for the Inventory

Goals of an inventory

The goals of an inventory include determination of the tract boundary, a statement of what is to be described by the inventory, and the precision and associated confidence level of one or more of the estimates.

The example used in this report will be for a tract of hardwood timber hypothetically having an area of 200 acres. The goal of this inventory is to estimate the volume and board foot content of the timber on the tract. Estimates will be on a per acre basis. The precision of the overall estimate of volume should have a half confidence interval that is 20% of the estimate or less at the 95% confidence level.

Defining merchantability standards, grades, and strata

In a PMD inventory, first- and second-stage trees are grouped by strata. The coefficients for one set of regression equations are calculated from second-stage trees in each stratum. A regression equation predicts volume, biomass, or board foot content from D^2H. A set of regression equations consists of an equation to predict volume and an equation to predict biomass for each grade expected in a particular stratum; the set of equations may also include an equation to predict board foot content for one grade in the stratum. Number of trees in the population and mean D^2H are estimated by stratum from first-stage trees and used with regression equations to get the final estimates for the inventory.

Merchantability standards are the minimum and maximum diameters and heights for trees to be considered for various products. Depending on the purpose of the inventory, the merchantability standards may be specific or broad. Furthermore, PTMODEL has a number of options to specify such tree dimensions as minimum top diameter, thus allowing adjustment of the standards after the data are collected. Familiarity with the options of the computer program and a detailed list of the desired output will allow efficient planning and development of clear, unambiguous definitions for the field crews.

Grades are used to describe the quality or potential product of tree sections. The bole of each second-stage tree is divided into sections of constant taper and similar quality. Diameter and height are measured at each end of each section, and a code for grade is assigned each section. Codes for grade can be up to two numbers or letters. Four codes for grade will be used in the case study: ST for sawtimber, PW for whole-tree pulpwood, TW pulpwood over sawtimber, and XX for cull. PTMODEL will process data for up to 33 grades per stratum.

Inventory results can be improved by stratification. In a PMD inventory, a set of regression equations is calculated for each stratum. By grouping species of similar form into strata, more accurate predictions can be achieved; for example, strata could be (1) pines, (2) hardwoods with excurrent form, and (3) hardwoods with decurrent form. Accuracy can also be increased by stratifying trees based on the end product. For example, one stratum could be for sawtimber trees, one for pulpwood trees, and one for trees that could be either. However, defining a large number of strata will require that a large number of second-stage trees be selected and measured to achieve an adequate sample in each stratum. PTMODEL will process up to nine strata.

Defining merchantability standards and strata--case study

In the case study, trees from 5.0 inches to 10.9 inches diameter (D) were pulpwood. Trees 11.0 inches and larger were sawtimber. To be sawtimber, trees had to have at least one 8-foot log and be of sufficient quality to produce lumber. Measurements were taken beyond the minimum 4-inch top diameter if the stem was utilizable.

Initially, all trees were grouped in stratum 1. The number of sample points and second-stage trees were calculated to achieve desired results. Sample points and second-stage trees were selected. The data were processed for the full output from PTMODEL.

Next, a second data set was developed by defining four strata based on species groups. Pines were stratum 1; oaks, stratum 2; yellow-poplar, stratum 3; and other hardwood species, stratum 4. Additional second-stage trees were selected to maintain the standard error of the estimate at the desired level.

Determining sample size--principles and procedures

In PMD sampling, the precision of the estimate is a function of the number of sample points and the number of second-stage trees. Many combinations of the two can provide the desired precision. The precision of the final estimate will be calculated by jackknifing or bootstrapping, computer-intensive techniques described later in this report. Equation 1, below, presented by Grosenbaugh (1973) for point-3P sampling, offers a reasonable approximation of sample sizes for PMD dependent sampling.

$$E\% = \left[\frac{(C_1 * t_1)^2}{n_1} + \frac{(C_2 * t_2)^2}{n_2}\right] \quad (1)$$

where:

$E\%$ = desired precision of the inventory

C_1 = coefficient of variation among accumulated height of trees on sample points

C_2 = coefficient of variation of the ratio of volume to D^2H among second-stage trees

n_1 & n_2 = number of sample points and number of second-stage trees, respectively

t_1 & t_2 = Student's t for desired level of confidence and (n_1-1) & (n_2-1) df, respectively

PTM_SIZE.BAS prompts the user for information and then calculates the sample sizes for PMD sampling using equation 1. The user supplies the minimum and maximum number of sample points to consider, coefficients of variation, and costs of measuring sample points and second-stage trees. The user can also specify an increment for sample points; for example, an increment of three results in calculations for every third number of sample points, thus reducing the size of the output. Coefficients of variation, and costs of measuring sample points and second-stage trees, can come from previous inventories or from a small, preliminary inventory.

Given C_1 and C_2, there are many combinations of n_1 and n_2 to achieve the desired level of precision. PTM_SIZE.BAS calculates the number of second-stage trees needed to get the desired precision for each number of sample points specified by the user. There is a minimum number of sample points to achieve the desired precision for C_1. When the number of sample points is less than this minimum, a message "DESIRED PRECISION NOT POSSIBLE" will be printed. Also, n_1 can get so large that n_2 is less than 10. For these a message "NO. OF SECOND STAGE TREES LESS THAN 10" will be printed.

After all the information is entered, a table (shown in **Figure 1**) of candidate sample sizes that will result in the desired precision is printed. The table also includes the cost for each combination of n_1 and n_2, and n_1/n_2. These are used in selecting the most efficient combination for a particular inventory.

Determining sample size--case study

For the case study, 10 sample points were randomly selected from the 73 in the data set. These were used for determining the coefficient of variation of the accumulated merchantable heights within sample points. Ten second-stage trees were also randomly selected for determining the coefficient of variation of volume divided by D^2H. The results of this preliminary sample are presented in **Table 1**.

Initially, these results were used with PTM_SIZE.BAS to calculate the number of second-stage trees for 10 to 100 sample points with an increment of 10, that is for 10, 20, 30, 40 .... Number of second-stage trees was only printed for 30 sample points; 10 and 20 points were too few to achieve the desired precision while 40 or more points resulted in fewer than 10 second-stage trees. These results were the basis for a second run with a range of 22 to 38 and an increment of two. **Figure 1** was the result.

Two combinations of sample points and second-stage trees have equal minimum cost of \$780: 30 points with 18 trees and 32 points with 14 trees. To select between these two combinations, the number

TABLE OF NUMBER OF SAMPLE POINTS AND SECOND-STAGE TREES
TO GET DESIRED SAMPLING ERROR AND ASSOCIATED COST OF EACH COMBINATION
(Uses Grosenbaugh's formula for sampling error with point-Poisson sampling)

Fewest sample points to consider = 24
Most sample points to consider = 40
Increment for first-stage sample points = 2
Coefficient of variation among sample points = 50
Coefficient of variation among second-stage trees = 15
Cost of measuring a sample point = 20 dollars
Cost of measuring a second-stage tree = 10 dollars
Desired sampling error as a percent of the estimate = 20
Desired confidence coefficient as a percent = 95

No. of sample points (n1)	Number of second-stage trees (n2)	Estimated cost of n1 and n2 (dollars)	n1/n2
24	DESIRED PRECISION NOT POSSIBLE*		
26	DESIRED PRECISION NOT POSSIBLE*		
28	36	920	.7777778
30	18	780	1.666667
32	14	780	2.285714
34	11	790	3.090909
36	10	820	3.6
38	NO.OF SECOND STAGE TREES LESS THAN 10		
40	NO.OF SECOND STAGE TREES LESS THAN 10		

* - Desired precision not possible because variability among this few sample points is higher than the desired sampling error without considering variability among second-stage trees

Figure 1. Combinations of number of sample points and number of second-stage trees that give desired results for case study. Table was produced with microcomputer program PTM_SIZE.BAS.

Table 1. Results of a preliminary sample of 10 sample points and 10 second-stage trees.

BAF 10 sample points		Second-stage trees			
Point number	Accumulated merchantable height (ft.)+	Tree number	Volume ($ft.^3$)	D^2H ($ft.^3$)	Volume/D^2H
1	272	1	13.1	27.8	0.47
2	252	2	8.8	15.3	0.58
3	172	3	17.9	39.7	0.45
4	236	4	24.0	47.8	0.50
5	108	5	16.0	47.2	0.34
6	572	6	66.2	130.0	0.51
7	272	7	5.6	10.9	0.51
8	140	8	40.0	76.0	0.53
9	252	9	20.6	39.7	0.52
10	380	10	108.2	277.2	0.39
	$\bar{x} = 265.6$ $s = 132.4$ CV = 50%			$\bar{x} = 0.48$ $s = 0.07$ CV = 15%	

+Accumulated merchantable height is the sum of the estimated merchantable heights of the trees selected at a point with a BAF 10 prism.

of sample points per second stage tree (column 4) is used. Wood and Schreuder (1986) suggested this ratio should be between 1 and 2; thus, the combination of 30 sample points and 18 second-stage trees is used.

Preparing a D^2H interval list for selecting second-stage trees

Any tree on the tract may be selected as a second-stage tree. The method described here has been found to be practical because it distributes the second-stage trees over the range of tree sizes and over the tract. The method is to use a D^2H interval list prepared for each inventory. In this list the range from the smallest to the largest value of D^2H is divided into a number of intervals equal to the number of second-stage trees to be selected.

PTM_LIST.BAS is a BASIC program for producing D^2H interval lists on a microcomputer with a printer. The user supplies smallest and largest values of D^2H to be considered, and the number of second-stage trees for which intervals are needed. Also, the user inputs a coefficient to compress the intervals at either end of the overall range. Coefficients less than one, usually 0.5, result in intervals at the small end being narrow and intervals at the large end being wide; this is recommended because it helps reduce the number of intervals without trees at the large end of the range.

A D^2H interval list for second-stage trees--case study

Since the minimum diameter breast height and height considered on this inventory were 5.0 inches and 8 feet, respectively, the minimum D^2H was 1.39

cu.ft. The largest D^2H on the sample points in the preliminary sample was 277.22 cu.ft. (D = 21.8 inches and merchantable height = 84 feet). With this range of D^2H and the desired number of second-stage trees calculated above (18 trees), a D^2H list (**Figure 2**) was produced with PTM_LIST.BAS. Note that the coefficient of 0.5 has resulted in the width of the first interval being 2.76 while the last interval has a width of 27.9 cu.ft.

Equipment and data forms

Equipment for the first stage of a PMD inventory includes: compass, diameter tape, 100- or 200-foot (30 or 60m) tape, prism or angle gauge, data forms, and clipboard. For the second stage, a bark gauge, a dendrometer and associated equipment, data forms, and clipboard are needed. Other equipment may be needed to handle specific conditions or take specific data on a particular inventory.

During the main inventory, stratum, species, DBH, and height of trees on horizontal point samples, are recorded along with sample point and tree number (**Figures 3** and **4**).

Each second-stage tree has one tree record and up to nine dendrometer records (**Figures 5** and **6**). The format of these records is very similar to STXMOD with the addition of wood density used to calculate biomass.

Conducting the Inventory

Principles

Once the goals of the inventory have been defined, the sample sizes determined and the equipment and forms assembled, the inventory can begin. First, the desired number of sample points is established using random sampling or a systematic grid with a random start. At each point, trees of interest are identified with a prism, relaskop, or other angle gauge. For each such tree, the stratum, species, diameter breast height, and height are recorded. The D^2H for each tree is calculated, and second-stage trees are selected using the D^2H interval list. This selection is done keeping in mind the rate of selection needed to spread the second-stage trees over all sample points and the range of D^2H; hazardous and atypical trees are ignored.

Second-stage trees can be dendrometered as they are selected, or marked and dendrometered as a separate operation. The choice depends on the skills of the field crew, the availability and transportability of dendrometers, etc. Whichever approach is used, clear instructions and objective definitions are needed to increase standardization among crews and to increase efficiency.

The second-stage trees are measured in detail. The measurements consist of either stem diameters and heights (for felled trees or direct measuring instruments) or data that are processed by PTMODEL to give diameter and height (most dendrometers). Second-stage tree data would also include the diameter breast height and height from the sample tree data, and information such as the type of dendrometer used, and the bark projection model desired. These are described in detail in **Figure 5**. Procedures for dendrometry and data collection follow those described for STXMOD (Chehock 1982).

Case study

Thirty sample points were randomly selected from those remaining after the preliminary sample. Data for trees on the first six sample points are presented in **Figure 7**. Using the D^2H interval list (**Figure 2**), second-stage trees were selected at the rate of about three trees for every five sample points. The 18 trees were in 13 intervals with five intervals being blank and five intervals having two trees each. One tree, a yellow-poplar, far exceeded the largest D^2H expected. Only trees in the preliminary sample were considered in determining the maximum value; in practice, the inventory crew would look beyond sample points for large trees avoiding this gross error.

D2H INTERVAL LIST FOR POINT-MODEL BASED SAMPLING Page 1
INTERVALS COMPRESSED AT SMALL END OF D2H RANGE COEF = .5

Minimum value of D2H per tree = 1.38889 cubic feet
Maximum value of D2H per tree = 277.2222 cubic feet
Number of trees to be dendrometered = 18

Stratum to use this list with :

Interval number	Bounds of interval of D2H Lower - Upper	Check when tree selected
1	1.38889 to 4.1536	
2	4.1536 to 8.395881	
3	8.395881 to 14.11573	
4	14.11573 to 21.31316	
5	21.31316 to 29.98815	
6	29.98815 to 40.14071	
7	40.14071 to 51.77084	
8	51.77084 to 64.87856	
9	64.87856 to 79.46381	
10	79.46381 to 95.52662	
11	95.52662 to 113.067	
12	113.067 to 132.085	
13	132.085 to 152.5805	
14	152.5805 to 174.5536	
15	174.5536 to 198.0042	
16	198.0042 to 222.9325	
17	222.9325 to 249.3383	
18	249.3383 to 277.2215	

Figure 2. D^2H interval list for case study. Numbers in last column are D^2H of trees selected for dendrometry. Table was produced with microcomputer program PTM_LIST.BAS.

RECORD COLUMN	ENTRY AND EXPLANATION	VARIABLE NAME	FORMAT
1-4	Number of sample plot, line or point [Enter 9999 after last sample tree record]	NOPLOT	I4
5-13	Multiplier for sample tree frequency	XTRA	F9.3
14-22	Divisor for sample tree frequency	XTRB	F9.3
23-26	Number of sample tree	KREENO	I4
27	Stratum of sample tree	LST	I1
28-31	Species code for sample tree	CLASS	A4
32-36	DBH of sample tree (inches to 0.1 or cm to 0.1)	DBH	F5.1
37-40	Height of sample tree (feet or meters)	SUMHT	F4.1

Figure 3. Description of sample tree data records for PTMODEL.

Processing with PTMODEL

Input to PTMODEL

The input stream to PTMODEL is shown in **Figure 8**. **Figure 9** is the input data for the example with only part of the sample tree data and part of the second-stage tree data. The first four input records describe the inventory and indicate the type of output desired (**Figure 10**). Records 1, 2, and 4 are similar to STXMOD control records 1, 2, and 10, respectively. Record 3 is for entering wood densities that apply to strata. These are used in converting volume to biomass.

The control records indicate information on the inventory (for example, number of sample points, type of sampling, etc.), desired output specifications (for example, upper stem diameters), and desired types of output (for example, individual tree detail, board foot tables, etc.). A header is produced as the first page of the output with an explanation of each option selected for the specific computer run. The first, second, and fourth control record are also reproduced at the top of each page of the output as a reference for the user.

One tree record and up to nine dendrometry records for each second-stage tree follow the control records. The data on these records are used to calculate the regression coefficients subsequently used to predict volume of first-stage trees. A record with 9997 in the first four columns indicates the end of the second-stage tree data.

The matrix of grade codes follows the second-stage tree data (**Figures 11 and 12**). One record per stratum is entered. All grade codes possible for trees in a stratum are entered even though some codes may not occur on some trees. This information is used to

Plot number 01–04	XTRA 05–13	XTRB 14–22	Tree number 23–26	Str 27	Tree species 28–31	Tree d.b.h. 32–36	Tree height 37–40	Calculated D^2H (not entered in computer)
						.		
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[The 40 columns of this form correspond to the first 40 columns of the computer record for sample tree data for PTMODEL]

Figure 4. Data tally form for trees selected on sample plots, lines, or points in point-model dependent sampling.

RECORD TYPE	RECORD COLUMN	ENTRY AND EXPLANATION	VARIABLE NAME	FORMAT
Tree	1-4	Tree number	KREENO	I4
	5	Record within tree: tree record = 0 or blank	JQ	I1
	6-9	Estimated height (feet or meters)	KPI	I4
	10	Stratum	LST	I1
	12-15	Class or species	BETATH	A4
	17-21	Diameter breast height (tenths of inches or millimeters)	DBH	F5.1
	22	Blank if input is U.S. units; + if input is in metric units	JIM	A1
	23	Blank or zero for Barr and Stroud FP-12 (uses subroutine SBRD) 1 for Barr and Stroud FP-15 (SBRD) 2 for direct measurements (DLIN) 3 for teletop (OPCL) 4 for transit dendrometer (OPFK) 5 for U.S. scale relaskop (OPFK) 6 for direct reading calipers (base=100 ft.) with cumulative height from base (OPCL) 7 for direct reading calipers (base=66 ft.) 8 for Todis (OPCL) 9 for Telerelaskop (OPFK) 10 for user written subroutine (OTHR) (dummy subroutine)	METH	I1
	24	1 for constant ratio of DIB to DOB 2 for curvilinearly increasing ratio above bh 3 for curvilinearly decreasing ratio above bh	MBK	I1
	25	0 or 1 — Unseen but usable material above last measured section of tree estimated by convex-conic-concave projection based on computer analysis of taper 2 — Unseen but usable material above last measured section of tree computed from user-entered conic taper rate and length. 3 or larger — Unseen but usable material above last measured section of tree estimated from user-supplied functions FFH3, FFS3, FFV3.	MUL	I1

Figure 5. Description of second-stage tree data records for PTMODEL (part 1 of 3).

RECORD TYPE	RECORD COLUMN	ENTRY AND EXPLANATION	VARIABLE NAME	FORMAT
Tree (cont.)	26	0, blank = no interpolation (tree processed exactly as measured). 1 = Interpolate to fixed top outside bark (the portion of the tree smaller than this will be discarded). 2 = Interpolate to fixed intermediate diameter outside bark. 3 = Interpolate both fixed top and intermediate diameter outside bark. 4 = Interpolate to fixed top inside bark. 5 = Interpolate to fixed intermediate diameter inside bark. 6 = Interpolate both fixed top and intermediate diameter inside bark.	JAM	I1
	27-30	Single bark thickness at breast height (tenths of inch or millimeters) (-009 for disregarding bark)	BKA	F4.1
	31-34	Second single bark thickness	BKB	F4.1
	36-38	Unseen merchantable length (feet or meters & tenths)	UMAXL	F3.0
	39-41	Rate of taper of unseen material (inches per foot or millimeters per meter) when MUL=2; set to dob/dbhob when MUL = 1	UDORT	F3.3
	62-71	Mass per unit volume (lbs./cu.ft. of kg/m^3)	TRDEN	F10.2
	72	Blank for trees with dendrometry records	TERM	A1
	73-76	Percent cull	DEDT	F4.0
	77-80	Number of sample plot, line or point that tree is associated with; second-stage trees may not be associated with a sample location, but PLOTNO may be useful to match tree data and error messages or section summary.	PLOTNO	I4

Figure 5. Description of second-stage tree data records for PTMODEL (part 2 of 3).

RECORD TYPE	RECORD COLUMN	ENTRY AND EXPLANATION		VARIABLE NAME	FORMAT
DENDRO-METER	1-4	Tree number		KREENO	I4
	5	Record within tree (1 - 9)		JQ	I1
	12-15	Trio of measurements related to stem	Section 1	TGRADS(1)	F4.1
	16-19	diameter and height of measurement	Section 1	FGRADS(1)	F4.1
	20-24	Details by dendrometer option in Chehock 1982.	Section 1	SINELV(1)	F5.1
	25-26	Grade of section having lower diameter described by previous trio of measurements.	Section 1	GAMATH(1)	A2
	27-30		Section 2	TGRADS(2)	F4.1
	31-34		Section 2	FGRADS(2)	F4.1
	35-39		Section 2	SINELV(2)	F5.1
	40-41		Section 2	GAMATH(2)	A2
	42-45		Section 3	TGRADS(3)	F4.1
	46-49		Section 3	FGRADS(3)	F4.1
	50-54		Section 3	SINELV(3)	F5.1
	55-56		Section 3	GAMATH(3)	A2
	57-60		Section 4	TGRADS(4)	F4.1
	61-64		Section 4	FGRADS(4)	F4.1
	65-69		Section 4	SINELV(4)	F5.1
	70-71		Section 4	GAMATH(4)	A2
	72	Blank when dendrometry readings continune on next record + when dendrometry readings interrupted by fork or change in instrument position. * for final dendrometry record		TERM	A1
	77-80	Number of sample plot, line or point that tree is associated with.		PLOTNO	I4
END-1	1-4	9997 to indicate end of volume tree data		KREENO	I4

Figure 5. Description of second-stage tree data records for PTMODEL (part 3 of 3).

TREE DATA (1 record per second-stage tree)

Tree number	Tree height	Str	Tree species	Tree d.b.h.	OPTIONS J	M	B	U	I	Single bark one	Single bark two	UML	UDT	Mass per unit volume	Percent cull	Sample pl, ln, or pt.#
01–04	06–09	10	12–15	17–21	22	23	24	25	26	27–30	31–34	36–38	39–41	62–71	73–76	77–80
				.												

DENDROMETRY DATA (up to 9 records per second-stage tree)

Tree number	Card	TGRADS	FGRADS	SINELV	GR	TGRADS	FGRADS	SINELV	GR	TGRADS	FGRADS	SINELV	GR	TGRADS	FGRADS	SINELV	GR	TGRADS	FGRADS	SINELV	GR	TERM	Sample plot, line, or point #
01–04	05	12–15	16–19	20–24	25 26	12–15	16–19	20–24	25 26	27–30	31–34	35–39	40 41	42–45	46–49	50–54	55 56	57–60	61–64	65–69	70 71	72	77–80
	1																						
	2																						
	3																						
	4																						
	5																						
	6																						
	7																						
	8																						
	9																						

Explanation of variables on tree data record:

- Str - stratum number
- J - English ( ) or metric (+) input units
- M - method or type of dendrometer used
- B - bark option desired
- U - method to handle unseen material
- I - projection and interpolation desired
- UML - length of unseen material
- UDT - diameter of unseen merch. material

Explanation of variables on dendrometry data records:

TGRADS, FGRADS, and SINELV are trio of readings for one stem measurement point from the dendrometer used.

GR is the grade code for the section below the stem measurement point described by the preceding trio of readings. It is left blank for the first trio of tree and for new measurement point

TERM is + to indicate start of new section or new setup location and ' to indicate end of dendrometry data for tree.

Figure 6. Data tally form for second-stage trees for PTMODEL.

Plot number	Tree number	Stratum code	Species code	DBH (in.)	Ht. (ft.)	D^2H (ft.^{3})
1	1	1	SO	15.0	42	65
1	2	1	SO	12.3	64	67
1	3	1	SO	17.4	60	126
1	4	1	SO	14.2	56	78
1	5	1	SO	15.8	56	97
1	6	1	SO	17.6	52	111<---
2	1	1	CO	5.9	20	4
3	1	1	SO	17.1	60	121
3	2	1	HIC	17.7	36	78
3	3	1	SO	16.9	56	111
3	4	1	HIC	6.5	24	7
3	5	1	BO	14.5	56	81<---
4	1	1	BO	8.6	8	4
4	2	1	WO	16.3	44	81
4	3	1	PO	12.3	24	25
4	4	1	SO	5.8	20	4
4	5	1	WO	7.6	28	11
4	6	1	PO	11.0	24	20
4	7	1	WO	5.8	12	2
5	1	1	SP	12.3	52	54
5	2	1	CO	11.3	48	42
5	3	1	WO	9.2	32	18
5	4	1	SP	10.2	44	31
5	5	1	WO	6.0	12	3
5	6	1	CO	8.8	28	15
5	7	1	CO	11.0	44	36
5	8	1	CO	5.7	20	4
5	9	1	HIC	14.8	40	60<---
5	10	1	SO	13.5	36	45
5	11	1	SP	10.3	56	41
6	1	1	XCO	17.8	28	61
6	2	1	CO	18.7	28	67
6	3	1	VP	13.3	44	54
6	4	1	XCO	28.0	36	196
6	5	1	CO	14.8	32	48
6	6	1	SP	6.5	16	4
6	7	1	CO	18.9	32	79
6	8	1	HIC	14.5	48	70
6	9	1	CO	19.2	36	92
6	10	1	SP	12.4	48	51
6	11	1	PO	10.3	12	88
6	12	1	CO	19.0	32	80
6	13	1	HIC	14.6	48	71

Figure 7. Tree data for first six sample points in example with calculated D^2H used in selecting second-stage trees. D^2H is truncated to whole cubic feet. Arrows at right indicate second-stage trees.

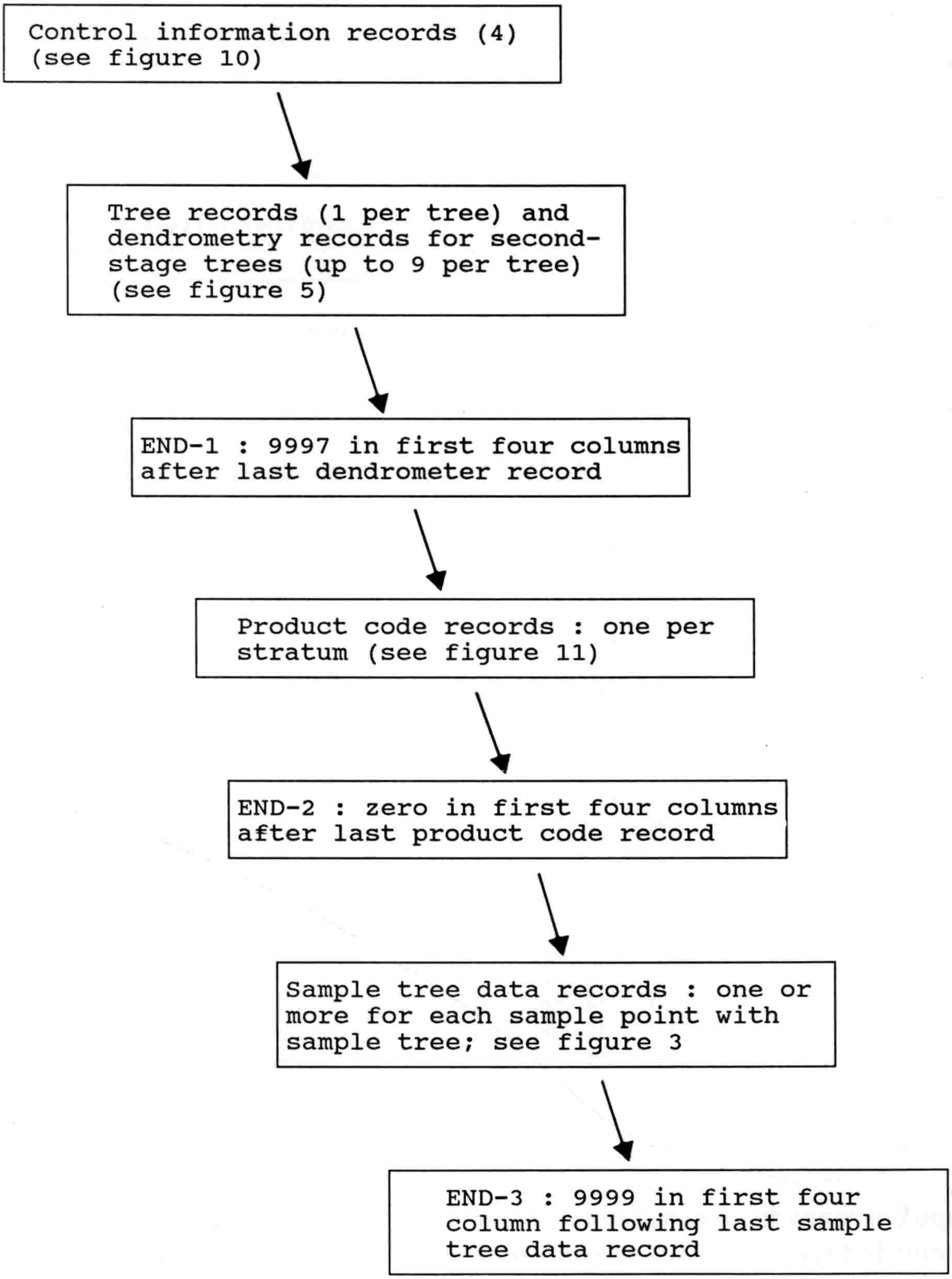

Figure 8. Input stream for PTMODEL starting with control records.

```
   CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM               TAES   1
   ONE STRATUM    1   30   30   80     10.  32303  1.5  300 23456543    TAES   2
   60.4                                                                TAES   3
01313 16.0  0.5  8.0   ST        3.0  8.0   3.0   8.0 3.0   11        TAES   4
  6   561*  SO   158 13 1 .90 .75                                            0001
  61      -99918.1  2.8      15.8  4.0PW0330083510183PW0349081011941PW  .550001
  62      0387078513916PW0413068915195PW0436067716050PW               * .550001
  5   561*  BO   145 13 3 .65 .85                                            0003
  51      -99916.1  2.0      14.7  4.0ST0461074813948ST0476069715394ST  .400003
  52      0478068016096ST0510059817613TW                              * .400003
-------------------------------------//-----------------------------------------
  5   161*  VP    60 12 1 .30 .30                                            0029
  51      -999 8.1  3.2       6.1  4.0PW0163052004744PW0145048311189PW  .300029
  52      0202038312752PW                                             * .300029
9997
  1TWPWSTXX
  0
  1                     11  SO  150 420
  1                     21  SO  123 640
  1                     31  SO  174 600
  1                     41  SO  142 560
  1                     51  SO  158 560
  1                     61  SO  176 520
  2                     11  CO   59 200
  3                     11  SO  171 600
  3                     21 HIC  177 360
  3                     31  SO  169 560
  3                     41 HIC   65 240
  3                     51  BO  145 540
-----------------//-------------------------
 30                     11  SP  124 680
 30                     21  BG  150 440
 30                     31  SP   95 360
 30                     41  SP  104 560
 30                     51  CO  126 440
 30                     61  SO  169 520
 30                     71 HIC   99 480
 30                     81  SP  158 640
 30                     91  CO  124 280
 30                    101  VP  115 400
 30                    111  SP  106 440
9999
9999
```

Figure 9. Input stream for example with tree and dendrometry data for three second-stage trees and sample tree data from four sample points.

add records with zero volume and zero biomass for grade codes which are possible, but not present, to the file of summed volume and biomass records; it also adds records with zero board foot content to the file of board foot records from strata with the selected grade code. A record with zero in the first four columns indicates the end of the matrix.

These records are the input for subsystem 1 of PTMODEL which calculates volume and biomass by grade, and board foot content for one specified grade.

The records for the first-stage trees follow. These are used to calculate the number of trees and mean D^2H. Finally, a record with 9999 in the first four columns indicates the end of the data for an inventory while a second such card indicates the end of the data for the current run.

Preparation of data--case study

All trees were initially assigned to stratum 1. Four grades were expected: ST for sawtimber, TW for topwood (material above the sawtimber used for fiber), PW for pulpwood (material in small trees wholly used for fiber), and XX for cull material.

Output from PTMODEL--the range of possibilities

The tables produced by PTMODEL are listed in **Figure 13**. Examples of most of these are shown in the sample output. Output through "Report by grade within dendrometered tree" are produced by subsystem 1; output from "Regression coefficients..." to "Summary report..." are from subsystem 2; the remainder are from subsystem 3.

The user may not want or need all types of the output. For example, board foot content may not be of interest or appropriate, so the various board foot tables would not be requested. The type of output printed on a particular run is controlled by six variables entered on the control records: LS2, LS3, LS5, IBRF, ISTN, and ISTK. **Figure 13** indicates which of these variables affects each type of printed output.

Three types of records with information on second-stage trees can also be produced with the appropriate values of control variables LS4 and IBP. They are volume output by section and tree, and board foot output by tree. These are residuals from the STXMOD code where they produced files for subsequent processing with other programs. They are not described further here because they have no apparent use with PTMODEL.

Output from PTMODEL--case study

Sample output from PTMODEL is in the appendix. Pages A1 to A13 are from the example using only 1 stratum for all species as developed in the example. Pages A14 to A19 are from two computer runs using four strata to group species with similar characteristics.

Each run starts with a header (pages A1, A14 and A17) describing the information on the input and options used on the particular computer run. All other pages of output have control records 1, 2, and 4 printed at the top.

The first part of the output is for the second-stage trees. Page A2 is the detailed calculations for three that were dendrometered, while page A3 has the results of board foot content for three trees having sections indicated as sawtimber. Page A4 is the summation by grade for six of the trees that were dendrometered; this information is the input for calculation of the regression coefficients. The regression coefficients for volume and biomass for each grade expected in stratum 1 are on page A5; regression coefficients are also presented for three log rules and volume of the sawtimber portion of appropriate trees. Finally, the bootstrap estimate of standard error is presented for the inventory. Note that the standard error is just over the desired goal of 10% of the estimate.

Pages A6 to A9 show output from the trees on sample points. For each sample tree, the predicted

RECORD NUMBER	RECORD COLUMN	ENTRY AND EXPLANATION	VARIABLE NAME	FORMAT
1	1-4	Blank (if not zero, terminate)	KREENO	I4
	5-68	Name of job	ALFATH	16A4
	73-76	Job identifier	CDID	A4
	80	Control record number	(not read)	
2	5-16	Short identifier	ADALFA	3A4
	19-20	Total number of strata	NSTR	I2
	21-25	Total number of plots, lines or points	NPLOTS	I5
	26-30	Largest plot, line, or point number recorded	JPLOTS	I5
	31-35	Largest estimated tree height to be recorded (feet or meters)	KQ	I5
	36-44	Plot area for fixed area plots(acres to 0.01 or hectares to 0.001). Horizontal distance multiplier * center line length for horizontal line samples (sq.ft./in. or m^2/ha). Basal area factor for horizontal point samples (sq.ft./acre or m^2/ha).	QI	F9.6
	45	Blank if input is U.S. units; + if input is metric units	JZ	A1
	46	1 for fixed area plots 2 for horizontal line samples 3 for horizontal point samples	LS1	I1
	47	0 or blank for no variance estimate 1 for jackknife estimate of variance 2 for bootstrap estimate of variance	LS2	I1
	48	0 or 1 for no printed individual tree detail 2 for printed individual dendrometered tree detail and sample tree detail 3 for printed individual dendrometered tree and tree-segment detail and sample tree detail	LS3	I1
	49	0 or 1 for no tree detail records as part of output 2 for tree detail records as part of output 3 for tree detail records and tree-segment records as part of output	LS4	I1
	50	Blank, 0 or 1 for no grade-yield (volume and biomass) and realization reports 2 for grade-yield & realization reports by class and grade 3 for grade-yield & realization reports by class and grade, and by section from first-stage trees	LS5	I1
	51-55	Exponent for weighted regression; see McClure et al. 1983; set to 1.5 by program if not defined by user	CAY	F5.2
	56-60	Number of samples to be selected for bootstrap estimate of variance; must be defined when LS2=2	NBOOT	I5
	61-69	Seed number for random number generator	ISEED	I9
	73-76	Job identifier	CDID	A4
	80	Control record number	(not read)	

Figure 10. Description of control records for PTMODEL (part 1 of 2).

RECORD NUMBER	RECORD COLUMN	ENTRY AND EXPLANATION	VARIABLE NAME	FORMAT
3	1-72	Mass per unit volume for each stratum (lbs./cu.ft. or kg/m^3)	STDEN(I)	9F8.0
	73-76	Job identifier	(not read)	
	80	Control record number	(not read)	
4	1	0 for bark deduction on all trees with bark measurements 1 for bark thickness to be ignored	NOBARK	I1
	2	Blank or 0 for no board foot reports 1 for log and tree board foot reports	IBFR	I1
	3	Blank or zero for no board foot records as output 1 for board foot log records as output 2 for board foot tree records as output 3 for board foot log and tree records as output	IBP	I1
	4	Blank or zero for no stand tables 1 for stand tables	ISTN	I1
	5	Blank or zero for no stock tables 1 for cubic foot or cubic meter stock tables 2 for board foot stock tables 3 for cubic foot or cubic meter, and board foot stock tables	ISTK	I1
	6-10	Maximum scaling length for logs (feet to 0.1 or meters to 0.1)	BL	F5.1
	11-15	Trim allowance for logs (feet to 0.1 or meters to 0.1)	TR	F5.1
	16-20	Minimum log length. Sections shorter than this will be disregarded. (feet to 0.1 or meters to 0.1)	AML	F5.1
	24-25	Product code for sections to be divided into logs and scaled	IST	A2
	36-40	Terminating diameter outside bark (dob) for interpolation (in. to 0.1 or cm to 0.1)	PLPDOB	F5.1
	41-45	Midpoint dob for interpolation (in. to 0.1 or cm to 0.1)	SAWDOB	F5.1
	46-50	Terminating diameter inside bark (dib) for interpolation (in. to 0.1 or cm to 0.1)	PLPDIB	F5.1
	51-55	Midpoint dib for interpolation (in. to 0.1 or cm to 0.1)	SAWDIB	F5.1
	56-60	Minimum fixed top diameter for projection (in. to 0.1 or cm to 0.1)	DPROJ	F5.1
	62	Blank or 0 for no deduction 1 for percentage deduction 2 for volume deduction	IDED	I1
	63	1 for deduction applied to International 1/4" 2 for deduction applied to Scribner 3 for deduction applied to Doyle 4 for deduction applied to cubic foot or cubic meter volume	ITD	I1
	73-76	Job identifier	(not read)	
	80	Control record number: read for last control record to indicate version of program	INM	I1

Figure 10. Description of control records for PTMODEL (part 2 of 2).

RECORD COLUMN	ENTRY AND EXPLANATION	VARIABLE NAME	FORMAT
1-4	Stratum [enter record with 0 (zero) for stratum to indicate last grade record has been entered]	LST	I1
5-6	Code for first section grade for which regression coefficients are to be calculated	GRADE (1)	A2
7-8	Code for second section grade for which regression coefficients are to be calculated	GRADE (2)	A2
. . .	. . .	. . .	
69-70	Code for 33rd section grade for which regression coefficients are to be calculated	GRADE (33)	A2
	[Codes entered for only those section grades possible for second-stage trees in a particular stratum]		
73-76	Job identifier	CDID	A4
77-80	Record number within section grade code records	PNUM	14

Figure 11. Description of records with matrix of section grade codes for PTMODEL.

volume and biomass by expected grade are calculated from the regression coefficients; the table on page A6 is part of the output from these calculations. Similar calculations are done for trees in strata expected to have sawtimber; page A7 shows part of the output from these calculations. Page A8 has part of the information calculated for each tree on sample points used to develop stand tables. The processing of second-stage tree and trees on sample points is summarized on page A9.

Examples of the summary tables from the inventory are on pages A10 to A13. First, all sections predicted in first-stage trees are sorted by class (species) and grade; part of this output is presented on page A10. These sections are then summed by class and grade (page A11, top). For each combination of class and grade, stock tables present volume and biomass (page A11, bottom); the only dbh classes represented are those for which trees were found on sample points.

Stand tables are produced for each class; the stand table for hickory is presented at the top of page A12. These are summed first by class (page A12, middle) and then by stratum (page A12, bottom).

Stock tables with the three common log rules and volume of the sawtimber portion of the trees on sample points are produced for each class with the grade for sawtimber (page A13, top); again, the only dbh classes represented are for trees recorded at the sample points. Totals for each class are then summarized (page A13, bottom).

When the second-stage trees and the trees on the sample points were sorted into four strata based on species, the number of regression coefficients increased from 12 to 48 (pages A15). Also, the standard error of the estimate increased to almost 32% of the estimate (page A16). To reduce the standard error to the desired level, the number of second-stage trees was increased from three to nine in stratum 1 (pines), kept at nine for stratum 2 (oaks), increased from three to six in stratum 3 (yellow-poplar) and increased from three to nine in stratum 4 (other); only six trees were used in stratum 3 because no more were available in the data set. New regression coefficients (page A18) and a new standard error (page A19) were calculated. The standard error with the increased number of second stage trees was less than 9% of the estimate.

Stratum	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade
0 0 0 0																																	

[Enter GRADE CODES (up to 33) that are possible for each stratum (up to 9)]

[The 70 columns on this form correspond to the first 70 columns of the computer record of the matrix of product codes for PTMODEL]

[Only include records for the strata up to the number indicated on control record 2 as NSTR]

[The zeros in columns 1 to 4 of the last line of this form indicates the end of the matrix]

Figure 12. Data entry form for grade codes by stratum for PTMODEL.

OUTPUT TABLES	SUBROUTINE	CONTROL VARIABLES	PAGE
Cover page with detailed description of options selected	HEAD		A1
Detailed section and/or tree report for second-stage trees (with section detail or without section detail)	ST22	LS3	A2
Board foot log and tree report for second-stage trees	BRPT	IBFR	A3
Report by grade within second-stage tree	PRP2		A4
Regression coefficients by stratum and grade calculated from second-stage trees	CALC		A5
Jackknife estimate of variance	JACK	LS2	
Bootstrap estimate of variance	BOOT	LS2	
Volume and biomass information for sample trees	RDLIST	LS3	A6
Board foot information for sample trees	RDLIST	LS3 & IBFR	A7
Stand table information for sample trees	RDLIST	LS3	A8
Summary report - number of second stage trees and sample trees processed; grade codes by stratum for regression	RDLIST		A9
Grade-yield and realization report by class and grade	PROD	LS5 & ISTK	A10
Grade-yield and realization report by DBH group (by class and grade)	PROD	LS5 & ISTK	A11
Number of trees by DBH group (by class)	STAN	ISTN	A12
Number of trees (by class)	STAN	ISTN	A12
Number of trees (by strata)	STAN	ISTN	A12
Board-foot volumes by DBH group (by class and grade)	BTAB	IBFR & ISTK	A13
Board-foot volume summary	BTAB	IBFR & ISTK	A13

Figure 13. Output tables produced by PTMODEL, subroutine printing each table, variables controlling printing, and page for each table in the example.

The Computer Program PTMODEL

Development

Since point-model dependent sampling was developed from point-Poisson sampling, PTMODEL includes large parts of STX (Grosenbaugh 1973), STXMOD (Space 1974) and STXENH (Rennie 1984). PTMODEL has three major subsystems. The first and third subsystems of PTMODEL are modified from STXMOD. The first subsystem processes data from second-stage trees to produce summaries of board foot content, and volume and biomass by grade, within trees. The second subsystem reads the matrix of grades expected in each stratum, and sample tree data; it then calculates weighted regression coefficients from the summarized dendrometry data and estimates the board foot content, and volume and biomass by grade, for first-stage trees; it also calculates either a jackknife or bootstrap estimate of variance. The third subsystem produces stand and stock tables and other summarizations to describe the population.

Configuration

PTMODEL consists of an executive program, a block data subprogram, 30 subroutines and four functions; **Figure 14** indicates the organization of these and also divides them into the three subsystems described in the introduction. The purpose of each function or subroutine is described in **Figure 15**; comments in the code of the program give a detailed description of the processing.

Computer environment

PTMODEL is available on two IBM-PC 5-1/4" disks or one 3-1/2" disk. The program code is in four files. The disk also includes files of sample data used to produce the output in this report, JCL used to run PTMODEL on an IBM 3081 computer at the University of Tennessee Computing Center (UTCC), and instructions for setting up and running PTMODEL.

PTMODEL is run at UTCC with 1024 kilobytes of memory, five disk storage areas, and three additional storage areas for output records. The program and data are stored as on-line disk files. Remote Job Entry (RJE) is used from the Conversational Monitor System (CMS) on an IBM 4381 computer to call the Job Control Language (JCL) file for execution in batch mode.

The disk also includes PTM_SIZE.BAS and PTM_LIST.BAS. These BASIC programs are used in planning an inventory using PMD dependent sampling as described above.

Finally, the disk includes files to produce the sample tree data form (**Figure 4**), the second-stage tree data form (**Figure 6**), and the product matrix data form (**Figure 12**). These are for use with WordPerfect™ software.

Details of Processing by PTMODEL

Determination of volume, biomass, and board foot content

Volume and board foot content of second-stage trees are determined using the procedures developed in STX and STXMOD. Smalian's formula is used for volume of each section defined by an upper and lower diameter and a length. Material beyond the last measurement is projected by the methods developed for STX. Board foot content by the three common log rules and volume are calculated for logs of the length specified by the user through control record 4; a shorter log is made from the remaining material if it is longer than the minimum specified by the user. Log scaling diameters are calculated by interpolation using the measured diameters and lengths.

For each section of the stem defined by an upper and lower diameter, biomass is calculated. This is the volume of the section multiplied by the weight per unit volume. Weight per unit volume can be by stratum (using control record 3) or by tree (using columns 62 to 71 on the second-stage tree record) or both. Both variables would be used for a stratum having a number of species with a range of weights per unit volume.

Executive program	Subroutines and functions				
PTM					
	TREE				
		ST11			
			HEAD		
		ST22			
			SBRD		
			DLIN		
			OPCL		
			OPFK		
			OTHR		
			GAPP		Subsystem 1
				FFH3	
				INTR	
				FFB3	
			FFS3		
			FFV3		
			LOGS		
		BRPT			
	PRP2				
		VSRT			
	MATRX				
	FILR				
	REGR				
		CALC			
		CONV			
	RDSAMP				Subsystem 2
	JACK				
	BOOT				
		RANGEN			
			RANDU		
	RDLIST				
	PREP				
		VSRT			
	PROD				
		SUBT			
	PREP				Subsystem 3
		VSRT			
	STAN				
	PREP				
		VSRT			
	BTAB				

The executive program PTM is followed by a block data subprogram, BLD. Subroutines or functions in the same column are called by the subroutine or program immediately above in the column to the left.

Figure 14. Organization of PTMODEL, its subsystems, functions, and subroutines.

Establishing a data set for regression

When a second-stage tree is assigned to a particular stratum, zero volume and biomass records are generated for each grade expected for that stratum but not represented in the tree's data. Also, if the grade equal to that to be considered sawtimber (IST on control record 4) is among the grades of the stratum of the tree, a zero board foot record will be added when a positive value is absent for the tree. Regression coefficients are calculated with non-zero and zero records by grade code and stratum. Predictions are calculated for each grade code expected in a sample tree's stratum.

As an example of how this might work, consider an inventory with one species and a wide range of sizes resulting in a variety of products. Small trees would have all pulpwood (PW) for their grade code; large trees would be all sawtimber (ST) and topwood (TW); trees of intermediate size could be either pulpwood or sawtimber and topwood. Three strata would be used with that stratum for the small trees having only the grade code PW, that for large trees only ST and TW, while the stratum for medium sized trees would have all three grade codes.

When the second-stage tree data are processed, regression coefficients would be calculated for PW for stratum 1, and ST and TW for stratum 3 with all the trees having volumes in each grade code (except some in stratum 3 might lack TW). All first-stage trees in stratum 1 would have a PW volume predicted and all those in stratum 3 a ST volume and a TW volume.

In the stratum with trees of intermediate size (stratum 2), coefficients would be calculated for all three grade codes. Some second-stage trees would have positive ST and TW volumes, and zero PW volumes, while others would have positive PW volumes and zero for ST and TW volumes. The regression coefficients reflect the average volume in ST, TW, and PW for the trees in this stratum; therefore, each sample tree would have a predicted volume for each of the three grade codes.

This result reflects the average, although no sample tree would have all three grade codes. Since only means are calculated from volume by grade, all trees contributing a small amount will lead to the same result as some trees contributing a large amount or all their volume and other none. Further, variance is calculated with total volume of trees, so grade code has no impact on it.

Estimation of regression coefficients

A weighted regression model is used in PTMODEL based on the results of McClure et al. (1983). The formulas for calculating the regression coefficients, a and b, are from Schreuder (1984).

Negative volume, biomass, and board foot estimates

Some first-stage trees may have negative volume and biomass estimates. These are trees with a small D^2H usually below the lower end of the D^2H range for the corresponding second-stage trees. The estimates calculated with the regression coefficients are checked before being stored and set to zero when negative. The frequency and basal area associated with trees having negative volume and biomass are retained. These are displayed in the various summary tables.

First-stage trees with negative board foot estimates are dropped from the board foot files and summary tables. Dropping these trees results in fewer trees in the board foot summaries than occur in the volume and biomass summaries.

Estimation of volume at various levels of pooling

The estimated volume presented for any level in the output is the sum of the expanded volumes for the first-stage trees in the particular category. The expanded volume is the frequency of the tree, based on the inventory parameters and the tree's size, times the tree's estimated volume. First-stage tree volume is estimated from the regression coefficients for the stratum of the tree.

SUBROUTINE OR FUNCTION	PURPOSE
TREE	Controls editing and reporting of second-stage tree data
ST11	Edits input and stores selected data for further processing
HEAD	Prints title page with description of current options
ST22	Edits dendrometry data from second-stage trees. Calculates section and tree volume and biomass. Prints detailed tree and section report. Stores tree and section detail records.
SBRD	Converts Barr and Stroud readings to diameter, elevation and range
DLIN	Converts direct linear measurements to diameter, elevation and range
OPCL	Converts data from modified teletop dendrometer, direct reading calipers and Todis dendrometer to diameter, elevation and range
OPFK	Converts data for the transit dendrometer and relaskops to diameter, elevation and range
OTHR	For user-developed subroutine to process dendrometer data*
GAPP	Supplies missing tree variables for ST22. Calculates upper stem diameters inside bark. Projects unmeasured upper stem diameters.
FFH3	For user-developed function for unseen length from seen part of tree*
INTR	Interpolates to specific top or midpoint diameter or both
FFB3	For user-developed function for bark. Calculates dib with bark model #3.
FFS3	For user-developed function for surface area of uppermost section*
FFV3	For user-developed function for volume of uppermost section*
LOGS	Divides tree measurements into logs by interpolation
BRPT	Calculates board foot values for logs and trees. Produces board foot log and tree report.
PRP2	Produces grade within tree reports for second-stage trees
VSRT	Sorts section or log or tree data
MATRX	Reads expected grade codes data by stratum

* Currently, these subroutines and functions do meaningless calculations that lead to erroneous results.

Figure 15. Description of subroutines and functions in PTMODEL (part 1 of 2).

SUBROUTINE OR FUNCTION	PURPOSE
FILR	Adds records with zero volume and biomass for second-stage trees not having positive values for grade codes expected for their stratum.Adds records with zero board foot value for second-stage trees not having positive values and in a stratum with a grade code equal to the value entered for IST.
REGR	Creates data subsets for each combination of grade code and stratum for which regression coefficients are to be calculated
CALC	Calculates weighted regression coefficients
CONV	Stores regression coefficients as subscripted variables for use with sample tree data
RDSAMP	Reads sample tree data and creates a volume and biomass record for each grade code expected for the tree's stratum. Creates a board foot record for when the tree's stratum includes the grade code equal the value entered for IST.
JACK	Calculates jackknife estimate of variance. Summary statistic is based on n*m pseudoestimates, where n is the number of second-stage trees is n and m is the number of sample plots, lines or points. Estimate i*j is calculated by dropping the ith second-stage tree from its stratum's regression coefficients and removing the data for the jth first-stage sample.
BOOT	Calculates bootstrap estimate of variance. User specifies the number of samples to use for the estimate. Each sample consists of n second-stage trees randomly selected with replacement from the n second-stage trees and m first-stage samples randomly selected with replacement from the m first-stage samples. When strata have been defined, the number of first-stage samples and second-stage trees selected in each stratum is equal to those in each stratum for the original data.
RANGEN	Calls random number generator on host computer to get uniformly distributed random numbers between zero and one
RDLIST	Lists volume and biomass, board foot and stand table information for first-stage trees. Produces summary table enumerating input data.
PREP	Supervises sorting of section or tree or board foot records
PROD	Produces grade-yield and realization reports. Produces volume and biomass stock tables by class and grade.
SUBT	Subtotals volume and biomass records
STAN	Produces stand tables by class and by stratum
BTAB	Produces board foot stock tables by class and grade

Figure 15. Description of subroutines and functions in PTMODEL (part 2 of 2).

Calculation of variance by jackknifing and bootstrapping

Jackknifing and bootstrapping are computer-based techniques to calculate standard error (Efron 1982, Efron and Gong 1983). They use the calculating power of computers in place of formulas for the variance derived specific for the sampling scheme.

For jackknifing in PTMODEL, each sample point and each second-stage tree are systematically removed from the data; a pseudoestimate is then calculated with the remaining data. Standard error is estimated from the pseudoestimates. With m sample points and n second-stage trees, there will be m*n pseudoestimates. In the case study, there are 30 sample points and 18 second-stage trees; therefore, the jackknife estimate of standard error is based on 540 pseudoestimates.

For the bootstrap estimate of standard error, the user enters the number of samples to be taken. Each sample will have as many sample points and second-stage trees as were in the actual inventory. These are randomly selected with replacement from the points and trees in the data set. In the case study, 100 samples were selected from the data. Each sample consisted of 30 sample points and 18 second-stage trees. The 30 sample points were randomly selected with replacement from the 30 sample points in the data set and the 18 second-stage trees were randomly selected with replacement from the 18 second-stage trees in the data set.

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Appendix

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==========================================================================================================
     PPPPPPPP       TTTTTTTTTTT      MM           MM       OOOO         DDDDDD      EEEEEEE      LL
     PPPPPPPPP      TTTTTTTTTTT      MMM         MMM     OO   OO        DDDDDDD     EEEEEEE      LL
     PP      PP         TT           MMMM       MMMM    OO     OO       DD     DD   EE           LL
     PP      PP         TT           MM MM     MM MM   OO       OO      DD      DD  EE           LL
     PPPPPPPPP          TT           MM  MM   MM  MM   OO       OO      DD      DD  EEEE         LL
     PPPPPPPP           TT           MM   MM MM   MM   OO       OO      DD      DD  EEEE         LL
     PP                 TT           MM    MMM    MM   OO       OO      DD      DD  EE           LL
     PP                 TT           MM    MMM    MM    OO     OO       DD     DDD  EE           LL
     PP                 TT           MM           MM     OO   OO        DDDDDDDD    EEEEEEEE     LLLLLLLLL
     PP                 TT           MM           MM       OOOO         DDDDDDD     EEEEEEEE     LLLLLLLLL
```

A COMPUTER PROCESSING SYSTEM FOR POINT-MODEL DEPENDENT SAMPLING

VERSION 1.2
1 JULY 1991

WRITTEN BY : JOHN C. RENNIE
DEPARTMENT OF FORESTRY, WILDLIFE AND FISHERIES
THE UNIVERSITY OF TENNESSEE
KNOXVILLE, TENNESSEE 37901-1071

==

OPTIONS SPECIFIED FOR CURRENT RUN

JOB NAME : CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM ,JOB IDENTIFIER: TAES,SHORT IDENTIFIER: ONE S

NUMBER OF STRATA : 1 NUMBER OF SAMPLE PLOTS, LINES OR POINTS : 30 LARGEST PLOT, LINE OR POINT NUMBER RECORDED :

MAXIMUM ESTIMATED TREE HEIGHT : 80 FT. SAMPLE EXPANSION FACTOR : 10.000000 SYSTEM OF UNITS USED : ENGLISH

TYPE OF SAMPLES USED : HORIZONTAL POINT SAMPLES TYPE OF VARIANCE ESTIMATE : BOOTSTRAP

TYPE OF PRINTED INDIVIDUAL TREE DETAIL OUTPUT : TREE AND SEGMENT DETAIL DETAIL STORED : NONE

EXPONENT FOR WEIGHTED REGRESSION FOR VOLUME : 1.50 NUMBER OF BOOTSTRAP SAMPLES REQUESTED : 300

MASS PER UNIT VOLUME BY STRATUM (LBS./CU.FT.): 60.

BARK DEDUCTED : BY TREE STAND TABLES REQUESTED : YES STOCK TABLES REQUESTED : BD.FT. & CU.FT.

GRADE-YIELD (VOLUME & BIOMASS) AND REALIZATION REPORTS REQUESTED : BY CLASS AND GRADE & BY SECTION

TYPE OF PRINTED BOARD FOOT REPORTS:LOG AND TREE REPORTS REQUESTED DETAIL STORED ON UNIT MPUB :BD.FT. LOG & TREE DET

LOG SPECIFICATIONS IN FEET : MAXIMUM SCALING LENGTH : 16.0 TRIM ALLOWANCE : 0.5 MINIMUM LENGTH : 8.0 PRODUCT CODE

TOP DOB FOR INTERPOLATION (INCHES) : 3.0 MID DOB FOR INTERPOLATION (INCHES) : 8.0

TOP DIB FOR INTERPOLATION (INCHES) : 3.0 MID DIB FOR INTERPOLATION (INCHES) : 8.0

MINIMUM TOP DIAMETER FOR PROJECTION (INCHES) : 3.0, PERCENTAGE DEDUCTION APPLIED TO : INTERNATIONAL 1/4

LOGICAL UNIT ASSIGNED TO DATA INPUT : 5, TO PRINTER : 6 ,TO DATA OUTPUT MPU, MPUB, MPUC : 1 2 3

AND FOR INTERMEDIATE STORAGE JW, JX, ITBF, ITBR, AND ITST : 4 8 9 10 11

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```
CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM          TAES    PAGE    1
ONE STRATUM     1   30     30     80 10.000000  32303  1.50    300
01313 16.0  0.5  8.0   ST  3.0  8.0  3.0  8.0  3.0 11 0            TAES    4

         DETAILED SECTION AND/OR TREE REPORT FOR SECOND-STAGE TREES

===============================================================================
BIOMASS/ VOLUME/ SURFACE / LENGTH /  DIB   /GRD /RANGE/   INSTRUMENT READINGS
  LBS. / CU.FT./  SQ.FT. /   FT.  /  IN.   /CODE/  FT./ TGRADS  FGRADS   SINELV
===============================================================================
  200.7     3.3      19.4      9.0      8.1  PW  69.1     43.6    67.7    0.6050
  347.9     5.8      27.1     10.2      8.4  PW  63.4     41.3    68.9    0.5195
  603.3    10.0      39.9     12.7     11.8  PW  58.1     38.7    78.5    0.3916
  478.2     7.9      30.4      9.3     12.2  PW  52.3     34.9    81.0    0.1941
  239.3     4.0      14.1      4.0     12.8  PW  49.9     33.0    83.5    0.0183
  216.7     3.6      11.3      2.8     14.1  PW   0.0      0.0    15.8    4.0000
    0.0     0.0       0.0      0.0     16.5       0.0    -99.9    18.1    2.8000
-------------------------------------------------------------------------------
 2086.1    34.5     142.2     48.0   SUMS
     TREE NUMBER =    6                15.8 = DBH(IN.) FREQUENCY =           1.000
     PREDICTION =   56 DBT(IN.) =  1.65 FORK   OPTIONS = 1311 UNSEEN MATERIAL
     CLASS =   SO   VALUE STRATUM =  1   BASAL AREA =  1.36 SQ.FT.
     PLOT OR POINT NUMBER     1   MASS/UNIT VOLUME =  60.40 LBS./CU.FT.
*******************************************************************************
  165.3     2.7      23.3     16.1      4.2  TW 101.7     51.0    59.8    0.7613
  201.4     3.3      20.7     10.3      6.8  ST  90.9      0.0     8.0    0.0000
  170.1     2.8      15.0      6.4      8.6  ST  84.0     47.8    68.0    0.6096
  533.8     8.8      40.0     14.5      9.4  ST  83.1     47.6    69.7    0.5394
  205.1     3.4      13.1      4.0     11.7  ST  77.1     46.1    74.8    0.3948
  127.5     2.1       7.3      2.0     13.2  ST   0.0      0.0    14.7    4.0000
    0.0     0.0       0.0      0.0     14.6       0.0    -99.9    16.1    2.0000
-------------------------------------------------------------------------------
 1403.2    23.2     119.4     53.2   SUMS
     TREE NUMBER =    5                14.5 = DBH(IN.) FREQUENCY =           1.000
     PREDICTION =   56 DBT(IN.) =  1.50 FORK   OPTIONS = 1313 UNSEEN MATERIAL
     CLASS =   BO   VALUE STRATUM =  1   BASAL AREA =  1.15 SQ.FT.
     PLOT OR POINT NUMBER     3   MASS/UNIT VOLUME =  60.40 LBS./CU.FT.
*******************************************************************************
  274.2     4.5      25.2     11.2      7.1  TW  53.5     35.8    65.7    0.6307
  545.8     9.0      40.0     14.1     10.1  ST  46.1     29.1    76.6    0.4902
  503.7     8.3      32.7     10.2     11.6  ST  39.2     17.8    84.4    0.2173
  220.8     3.7      13.6      4.0     12.8  ST  38.6     16.1    89.3   -0.0433
  298.9     4.9      15.8      4.0     13.0  ST   0.0      0.0    14.8    4.0000
    0.0     0.0       0.0      0.0     17.0       0.0    -99.9    18.7    4.0000
-------------------------------------------------------------------------------
 1843.4    30.5     127.2     43.5   SUMS
     TREE NUMBER =    9                14.8 = DBH(IN.) FREQUENCY =           1.000
     PREDICTION =   40 DBT(IN.) =  1.75 FORK   OPTIONS = 1313 UNSEEN MATERIAL
     CLASS =  HIC   VALUE STRATUM =  1   BASAL AREA =  1.19 SQ.FT.
     PLOT OR POINT NUMBER     5   MASS/UNIT VOLUME =  60.40 LBS./CU.FT.
*******************************************************************************
*******************************************************************************
```

```
CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM          TAES    PAGE   9
ONE STRATUM    1   30     30     80 10.000000  32303  1.50    300
01313 16.0  0.5  8.0    ST  3.0  8.0  3.0  8.0  3.0 11 0             TAES    4

                BOARD FOOT LOG AND TREE REPORT FOR SECOND-STAGE TREES

LOG LENGTH 16.0    TRIM ALLOWANCE  0.5    MINIMUM LENGTH  8.0      GRADE CODE  ST
    FT.                      FT.                   FT.
===============================================================================
TREE   /  LENGTH   / SCALING /  DIB /         BOARD FOOT CONTENT        /  VOLUME
 NO.  /     FT.   /LGTH. FT./  IN. /    INT. 1/4  / SCRIBNER /    DOYLE  /  CU.FT.
===============================================================================
           16.5      16.0       7.5          33.5        25.5       12.4       6.9
           16.5      16.0      10.0          65.2        55.4       36.4      13.7
            0.0       0.0      14.6           0.0         0.0        0.0       0.0
-------------------------------------------------------------------------------
   5       33.0      32.0      14.5=DBH /    98.7        81.0       48.9      20.6
     PREDICTION =    56 DBT(IN.)=  1.50/     0.0         0.0        0.0       0.0
     CLASS =   BO  VALUE STRATUM =  1 /     98.7        81.0       48.9      20.6
     PLOT OR POINT NUMBER =     3 FORM CLASS =  70.176 FREQUENCY =          1.000
     BASAL AREA =  1.15 SQ.FT.  PERCENT DEDUCTION =   0.00
*******************************************************************************
           15.8      15.0      10.1          60.6        52.4       34.5       9.8
           16.5      16.0      11.8          93.5        82.5       60.9      18.7
            0.0       0.0      17.0           0.0         0.0        0.0       0.0
-------------------------------------------------------------------------------
   9       32.3      31.0      14.8=DBH /   154.2       134.8       95.5      28.5
     PREDICTION =    40 DBT(IN.)=  1.75/     0.0         0.0        0.0       0.0
     CLASS =  HIC  VALUE STRATUM =  1 /    154.2       134.8       95.5      28.5
     PLOT OR POINT NUMBER =     5 FORM CLASS =  80.837 FREQUENCY =          1.000
     BASAL AREA =  1.19 SQ.FT.  PERCENT DEDUCTION =   0.00
*******************************************************************************
           16.5      16.0       8.3          41.9        33.4       18.3       6.2
           16.5      16.0       8.6          46.0        37.2       21.3       9.0
            0.0       0.0      11.5           0.0         0.0        0.0       0.0
-------------------------------------------------------------------------------
   2       33.0      32.0      11.3=DBH /    87.9        70.6       39.5      15.2
     PREDICTION =    40 DBT(IN.)=  0.95/     0.0         0.0        0.0       0.0
     CLASS =   CO  VALUE STRATUM =  1 /     87.9        70.6       39.5      15.2
     PLOT OR POINT NUMBER =     9 FORM CLASS =  76.976 FREQUENCY =          1.000
     BASAL AREA =  0.70 SQ.FT.  PERCENT DEDUCTION =   0.00
*******************************************************************************
```

```
ONE STRATUM    1   30    30    80 10.000000  32303  1.50   300
01313 16.0  0.5  8.0   ST  3.0  8.0  3.0  8.0  3.0 11 0            TAES   4

                    REPORT BY GRADE WITHIN SECOND-STAGE TREE

SECTION GRADE   LBS. OF BIOMASS CU.FT.IB VOLUME                          COUNT
==============================================================================
         ST           1279.44          21.18                                 3
         TW           1213.76          20.10                                 9
------------------------------------------------------------------------------
   9=TREE NO.         2493.20          41.28 SUMS  FREQ. =           1.00   12
 1=STRATUM  PLOT OR POINT NUMBER=    22  DBH =  15.0 IN.   EST. HT.=   64.0 FT.
******************************************************************************
         PW            265.89           4.40                                 5
------------------------------------------------------------------------------
   1=TREE NO.          265.89           4.40 SUMS  FREQ. =           1.00    5
 1=STRATUM  PLOT OR POINT NUMBER=    24  DBH =   7.0 IN.   EST. HT.=   36.0 FT.
******************************************************************************
         ST           1136.27          18.81                                 4
         TW            202.71           3.36                                 2
------------------------------------------------------------------------------
   9=TREE NO.         1338.97          22.17 SUMS  FREQ. =           1.00    6
 1=STRATUM  PLOT OR POINT NUMBER=    24  DBH =  12.4 IN.   EST. HT.=   48.0 FT.
******************************************************************************
         ST           5441.01          90.08                                 2
         TW           1550.84          25.68                                 2
         XX           9691.92         160.46                                 4
------------------------------------------------------------------------------
   4=TREE NO.        16683.77         276.22 SUMS  FREQ. =           1.00    8
 1=STRATUM  PLOT OR POINT NUMBER=    26  DBH =  36.2 IN.   EST. HT.=   76.0 FT.
******************************************************************************
         PW           1500.54          24.84                                 5
         XX            617.93          10.23                                 2
------------------------------------------------------------------------------
   2=TREE NO.         2118.47          35.07 SUMS  FREQ. =           1.00    7
 1=STRATUM  PLOT OR POINT NUMBER=    27  DBH =  19.5 IN.   EST. HT.=   56.0 FT.
******************************************************************************
         PW            255.64           4.23                                 4
------------------------------------------------------------------------------
   5=TREE NO.          255.64           4.23 SUMS  FREQ. =           1.00    4
 1=STRATUM  PLOT OR POINT NUMBER=    29  DBH =   6.0 IN.   EST. HT.=   16.0 FT.
******************************************************************************
==============================================================================
 WTD TOTALS          54126.15         896.13         984.28          18.00  123
```

ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

REGRESSION COEFFICIENTS BY STRATUM AND GRADE CALCULATED FROM SECOND-STAGE TREES

COEFFICIENT SET NUMBER	STRATUM NUMBER	GRADE CODE	COEFFICIENTS FOR WEIGHTED REGRESSION A	B	OUTPUT PRODUCT	NUMBER OF TREES
1	1	TW	-0.23779893	0.00042587	VOLUME	18
2	1	TW	-14.36302380	0.02572236	BIOMASS	18
3	1	PW	3.98653316	-0.00001228	VOLUME	18
4	1	PW	240.78662100	-0.00074172	BIOMASS	18
5	1	ST	-0.78935784	0.00175951	VOLUME	18
6	1	ST	-47.67732240	0.10627466	BIOMASS	18
7	1	ST	-6.65238476	0.01060845	BOARD FT.(INT.)	18
8	1	ST	-6.59264183	0.00953137	BOARD FT.(SCRB.)	18
9	1	ST	-6.68066502	0.00767818	BOARD FT.(DOYLE)	18
10	1	ST	-0.75741780	0.00172471	VOLUME (CU.FT.)	18
11	1	XX	-0.54697692	0.00032743	VOLUME	18
12	1	XX	-33.03738400	0.01977667	BIOMASS	18

ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

BOOTSTRAP ESTIMATE OF VARIANCE

ESTIMATE OF THE MEAN----------------------	1504.0806
STANDARD DEVIATION------------------------	160.5396
STD.DEV. AS A PERCENT OF THE MEAN---------	10.6736
NUMBER OF BOOTSTRAP SAMPLES----------------------	300
NUMBER OF SECOND-STAGE TREES----------------------	18
NUMBER OF SAMPLE PLOTS, LINES OR POINTS ----------	30

ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

VOLUME AND BIOMASS INFORMATION FOR FIRST-STAGE TREES

PLOT NUMBER	TREE NUMBER	VALUE STRATUM	CLASS	GRADE NUMBER	GRADE CODE	DBH IN.	HEIGHT FT.	FREQUENCY	VOLUME CU.FT.	BIOMASS LBS.
1	1	1	SO	1	TW	15.0	42.00	0.272	3.79	228.71
1	1	1	SO	2	PW	15.0	42.00	0.272	3.87	233.78
1	1	1	SO	3	ST	15.0	42.00	0.272	15.84	956.62
1	1	1	SO	4	XX	15.0	42.00	0.272	2.55	153.85
1	2	1	SO	1	TW	12.3	64.00	0.404	3.89	234.70
1	2	1	SO	2	PW	12.3	64.00	0.404	3.87	233.60
1	2	1	SO	3	ST	12.3	64.00	0.404	16.25	981.33
1	2	1	SO	4	XX	12.3	64.00	0.404	2.62	158.45
1	3	1	SO	1	TW	17.4	60.00	0.202	7.50	452.90
1	3	1	SO	2	PW	17.4	60.00	0.202	3.76	227.31
1	3	1	SO	3	ST	17.4	60.00	0.202	31.17	1882.86
1	3	1	SO	4	XX	17.4	60.00	0.202	5.40	326.22
1	4	1	SO	1	TW	14.2	56.00	0.303	4.57	276.09
1	4	1	SO	2	PW	14.2	56.00	0.303	3.85	232.41
1	4	1	SO	3	ST	14.2	56.00	0.303	19.08	1152.36
1	4	1	SO	4	XX	14.2	56.00	0.303	3.15	190.28
1	5	1	SO	1	TW	15.8	56.00	0.245	5.72	345.23
1	5	1	SO	2	PW	15.8	56.00	0.245	3.81	230.42
1	5	1	SO	3	ST	15.8	56.00	0.245	23.81	1438.03
1	5	1	SO	4	XX	15.8	56.00	0.245	4.03	243.44
1	6	1	SO	1	TW	17.6	52.00	0.197	6.62	399.96
1	6	1	SO	2	PW	17.6	52.00	0.197	3.79	228.84
1	6	1	SO	3	ST	17.6	52.00	0.197	27.55	1664.14
1	6	1	SO	4	XX	17.6	52.00	0.197	4.73	285.52
2	1	1	CO	1	TW	5.9	20.00	1.756	0.06	3.54
2	1	1	CO	2	PW	5.9	20.00	1.756	3.98	240.27
2	1	1	CO	3	ST	5.9	20.00	1.756	0.44	26.31
2	1	1	CO	4	XX	5.9	20.00	1.756	0.00	0.00
3	1	1	SO	1	TW	17.1	60.00	0.209	7.23	436.93
3	1	1	SO	2	PW	17.1	60.00	0.209	3.77	227.77
3	1	1	SO	3	ST	17.1	60.00	0.209	30.08	1816.87
3	1	1	SO	4	XX	17.1	60.00	0.209	5.20	313.94
3	2	1	HIC	1	TW	17.7	36.00	0.195	4.57	275.74
3	2	1	HIC	2	PW	17.7	36.00	0.195	3.85	232.42
3	2	1	HIC	3	ST	17.7	36.00	0.195	19.06	1150.93
3	2	1	HIC	4	XX	17.7	36.00	0.195	3.15	190.01
3	3	1	SO	1	TW	16.9	56.00	0.214	6.57	397.04
3	3	1	SO	2	PW	16.9	56.00	0.214	3.79	228.92
3	3	1	SO	3	ST	16.9	56.00	0.214	27.35	1652.09
3	3	1	SO	4	XX	16.9	56.00	0.214	4.69	283.27
3	4	1	HIC	1	TW	6.5	24.00	1.447	0.19	11.72
3	4	1	HIC	2	PW	6.5	24.00	1.447	3.97	240.03
3	4	1	HIC	3	ST	6.5	24.00	1.447	0.99	60.09
3	4	1	HIC	4	XX	6.5	24.00	1.447	0.00	0.00
3	5	1	BO	1	TW	14.5	42.00	0.291	3.52	212.78
3	5	1	BO	2	PW	14.5	42.00	0.291	3.88	234.24
3	5	1	BO	3	ST	14.5	42.00	0.291	14.75	890.78

CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM TAES PAGE 37
ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

BOARD FOOT INFORMATION FOR FIRST-STAGE TREES

PLOT NUMBER	TREE NUMBER	VALUE STRATUM	CLASS	DBH IN.	HEIGHT FT.	FREQUENCY	BOARD FOOT CONTENT INT.1/4"	SCRIBNER	DOYLE	VOLUME CU.FT.
1	1	1	SO	15.0	42.00	0.272	93.60	83.48	65.88	15.54
1	2	1	SO	12.3	64.00	0.404	96.06	85.70	67.66	15.94
1	3	1	SO	17.4	60.00	0.202	186.06	166.55	132.80	30.57
1	4	1	SO	14.2	56.00	0.303	113.14	101.03	80.02	18.72
1	5	1	SO	15.8	56.00	0.245	141.65	126.65	100.66	23.35
1	6	1	SO	17.6	52.00	0.197	164.22	146.93	117.00	27.02
3	1	1	SO	17.1	60.00	0.209	179.47	160.63	128.03	29.50
3	2	1	HIC	17.7	36.00	0.195	112.99	100.91	79.92	18.69
3	3	1	SO	16.9	56.00	0.214	163.02	145.85	116.13	26.83
3	4	1	HIC	6.5	24.00	1.447	4.10	3.07	1.11	0.99
3	5	1	BO	14.5	42.00	0.291	87.03	77.57	61.12	14.47
4	2	1	WO	16.3	44.00	0.230	117.36	104.83	83.08	19.41
4	3	1	PO	12.3	24.00	0.404	31.87	28.02	21.20	5.50
4	5	1	WO	7.6	28.00	1.058	10.50	8.82	5.74	2.03
4	6	1	PO	11.0	24.00	0.505	24.15	21.09	15.62	4.25
5	1	1	SP	12.3	52.00	0.404	76.81	68.39	53.72	12.81
5	2	1	CO	11.3	48.00	0.479	58.37	51.83	40.38	9.81
5	3	1	WO	9.2	32.00	0.722	22.08	19.22	14.12	3.91
5	4	1	SP	10.2	44.00	0.587	41.91	37.04	28.47	7.14
5	6	1	CO	8.8	28.00	0.789	16.35	14.07	9.97	2.98
5	7	1	CO	11.0	44.00	0.505	49.83	44.15	34.20	8.42
5	9	1	HIC	14.8	40.00	0.279	86.29	76.92	60.59	14.35
5	10	1	SO	13.5	36.00	0.335	62.95	55.94	43.70	10.56
5	11	1	SP	10.3	56.00	0.576	56.37	50.03	38.94	9.49
6	1	1	XCO	17.8	28.00	0.193	87.46	77.97	61.44	14.54
6	2	1	CO	18.7	28.00	0.175	97.22	86.73	68.50	16.13
6	3	1	VP	13.3	44.00	0.346	75.91	67.59	53.08	12.67
6	4	1	XCO	28.0	36.00	0.078	292.76	262.42	210.03	47.92
6	5	1	CO	14.8	32.00	0.279	67.71	60.22	47.14	11.33
6	7	1	CO	18.9	32.00	0.171	114.61	102.36	81.09	18.96
6	8	1	HIC	14.5	48.00	0.291	100.41	89.60	70.81	16.65
6	9	1	CO	19.2	36.00	0.166	134.13	119.90	95.22	22.13
6	10	1	SP	12.4	48.00	0.397	71.64	63.75	49.99	11.97
6	11	1	PO	10.3	12.00	0.576	6.85	5.54	3.09	1.44
6	12	1	CO	19.0	32.00	0.169	115.90	103.51	82.02	19.17
6	13	1	HIC	14.6	48.00	0.287	101.89	90.93	71.88	16.89
7	1	1	CO	8.9	12.00	0.772	3.43	2.47	0.62	0.88
7	2	1	CO	9.9	16.00	0.624	9.98	8.35	5.36	1.95
7	3	1	CO	6.9	20.00	1.284	3.45	2.48	0.63	0.88
7	4	1	HIC	7.4	24.00	1.116	7.29	5.93	3.41	1.51
7	5	1	SO	13.3	16.00	0.346	23.37	20.38	15.05	4.12
7	6	1	SO	14.2	28.00	0.303	53.24	47.22	36.67	8.98
7	7	1	SO	7.8	16.00	1.005	3.67	2.69	0.79	0.92
7	8	1	HIC	8.1	16.00	0.931	4.48	3.41	1.38	1.05
7	9	1	SP	7.7	20.00	1.031	5.93	4.71	2.42	1.29
8	1	1	SO	20.4	48.00	0.147	205.26	183.80	146.70	33.69
8	2	1	CO	14.1	40.00	0.307	77.71	69.20	54.38	12.96

ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

STAND TABLE INFORMATION FOR FIRST-STAGE TREES

PLOT NUMBER	TREE NUMBER	VALUE STRATUM	CLASS	DBH IN.	HEIGHT FT.	FREQUENCY	BASAL AREA SQ.FT.
1	1	1	SO	15.0	42.00	0.272	1.2272
1	2	1	SO	12.3	64.00	0.404	0.8252
1	3	1	SO	17.4	60.00	0.202	1.6513
1	4	1	SO	14.2	56.00	0.303	1.0998
1	5	1	SO	15.8	56.00	0.245	1.3616
1	6	1	SO	17.6	52.00	0.197	1.6895
2	1	1	CO	5.9	20.00	1.756	0.1899
3	1	1	SO	17.1	60.00	0.209	1.5948
3	2	1	HIC	17.7	36.00	0.195	1.7087
3	3	1	SO	16.9	56.00	0.214	1.5578
3	4	1	HIC	6.5	24.00	1.447	0.2304
3	5	1	BO	14.5	42.00	0.291	1.1467
4	1	1	BO	8.6	8.00	0.826	0.4034
4	2	1	WO	16.3	44.00	0.230	1.4491
4	3	1	PO	12.3	24.00	0.404	0.8252
4	4	1	SO	5.8	20.00	1.817	0.1835
4	5	1	WO	7.6	28.00	1.058	0.3150
4	6	1	PO	11.0	24.00	0.505	0.6600
4	7	1	WO	5.8	12.00	1.817	0.1835
5	1	1	SP	12.3	52.00	0.404	0.8252
5	2	1	CO	11.3	48.00	0.479	0.6964
5	3	1	WO	9.2	32.00	0.722	0.4616
5	4	1	SP	10.2	44.00	0.587	0.5674
5	5	1	WO	6.0	12.00	1.698	0.1963
5	6	1	CO	8.8	28.00	0.789	0.4224
5	7	1	CO	11.0	44.00	0.505	0.6600
5	8	1	CO	5.7	20.00	1.881	0.1772
5	9	1	HIC	14.8	40.00	0.279	1.1947
5	10	1	SO	13.5	36.00	0.335	0.9940
5	11	1	SP	10.3	56.00	0.576	0.5786
6	1	1	XCO	17.8	28.00	0.193	1.7281
6	2	1	CO	18.7	28.00	0.175	1.9073
6	3	1	VP	13.3	44.00	0.346	0.9648
6	4	1	XCO	28.0	36.00	0.078	4.2761
6	5	1	CO	14.8	32.00	0.279	1.1947
6	6	1	SP	6.5	16.00	1.447	0.2304
6	7	1	CO	18.9	32.00	0.171	1.9483
6	8	1	HIC	14.5	48.00	0.291	1.1467
6	9	1	CO	19.2	36.00	0.166	2.0106
6	10	1	SP	12.4	48.00	0.397	0.8386
6	11	1	PO	10.3	12.00	0.576	0.5786
6	12	1	CO	19.0	32.00	0.169	1.9689
6	13	1	HIC	14.6	48.00	0.287	1.1626
7	1	1	CO	8.9	12.00	0.772	0.4320
7	2	1	CO	9.9	16.00	0.624	0.5346
7	3	1	CO	6.9	20.00	1.284	0.2597
7	4	1	HIC	7.4	24.00	1.116	0.2987

CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM TAES PAGE 47
ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

SUMMARY REPORT

SECOND-STAGE TREES AND FIRST-STAGE TREES PROCESSED; GRADE CODES BY STRATUM FOR REGRESSION

SECOND-STAGE TREES

NUMBER OF SECOND-STAGE TREES	18
NUMBER OF VOLUME & BIOMASS SECTIONS FROM SECOND-STAGE TREES	123
NUMBER OF SUMMED VOLUME & BIOMASS SECTIONS FROM SECOND-STAGE TREES	33
NUMBER OF SUMMED VOLUME & BIOMASS SECTIONS FOR REGRESSION	72
NUMBER OF SUMMED BOARD FOOT SECTIONS FROM SECOND-STAGE TREES	13
NUMBER OF SUMMED BOARD FOOT SECTIONS FOR REGRESSION	18

FIRST-STAGE TREES

NUMBER OF FIRST-STAGE TREES	208
NUMBER OF VOLUME & BIOMASS RECORDS FROM FIRST-STAGE TREES	832
NUMBER OF BOARD FOOT RECORDS FROM FIRST-STAGE TREES	192
NUMBER OF FIRST-STAGE TREE RECORDS FOR STAND TABLES	208

LIST OF GRADE CODES FOR WHICH REGRESSION COEFFICIENTS ARE TO BE CALCULATED

STRATUM/ NUMBER /	GRADE CODE
1	TW PW ST XX

GRADE-YIELD AND REALIZATION REPORT OF FIRST-STAGE TREE SECTIONS
SORTED BY CLASS AND GRADE

PLOT	TREE	STRATUM	SECT.NO.	CLASS	GR	TR.DBH IN.	TR.HT. FT.	FREQ.	TR.VOL. CU.FT.	TR.BIOM. LBS.
15	3	2	1	BG	PW	7.9	28.00	0.979	3.97	239.49
15	7	2	1	BG	PW	10.8	44.00	0.524	3.92	236.98
30	2	2	1	BG	PW	15.0	44.00	0.272	3.86	233.44
15	3	3	1	BG	ST	7.9	28.00	0.979	2.29	138.04
15	7	3	1	BG	ST	10.8	44.00	0.524	8.24	497.74
30	2	3	1	BG	ST	15.0	44.00	0.272	16.63	1004.44
15	3	1	1	BG	TW	7.9	28.00	0.979	0.51	30.59
15	7	1	1	BG	TW	10.8	44.00	0.524	1.95	117.65
30	2	1	1	BG	TW	15.0	44.00	0.272	3.98	240.29
15	3	4	1	BG	XX	7.9	28.00	0.979	0.03	1.52
15	7	4	1	BG	XX	10.8	44.00	0.524	1.13	68.46
30	2	4	1	BG	XX	15.0	44.00	0.272	2.69	162.75
12	5	2	1	BL	PW	12.0	20.00	0.424	3.95	238.65
12	5	3	1	BL	ST	12.0	20.00	0.424	4.28	258.39
12	5	1	1	BL	TW	12.0	20.00	0.424	0.99	59.72
12	5	4	1	BL	XX	12.0	20.00	0.424	0.40	23.92
3	5	2	1	BO	PW	14.5	42.00	0.291	3.88	234.24
4	1	2	1	BO	PW	8.6	8.00	0.826	3.98	240.35
27	3	2	1	BO	PW	14.6	24.00	0.287	3.92	236.99
3	5	3	1	BO	ST	14.5	42.00	0.291	14.75	890.78
4	1	3	1	BO	ST	8.6	8.00	0.826	0.25	15.20
27	3	3	1	BO	ST	14.6	24.00	0.287	8.21	496.01
3	5	1	1	BO	TW	14.5	42.00	0.291	3.52	212.78
4	1	1	1	BO	TW	8.6	8.00	0.826	0.01	0.86
27	3	1	1	BO	TW	14.6	24.00	0.287	1.94	117.23
3	5	4	1	BO	XX	14.5	42.00	0.291	2.34	141.60
4	1	4	1	BO	XX	8.6	8.00	0.826	0.00	0.00
27	3	4	1	BO	XX	14.6	24.00	0.287	1.13	68.14
26	2	2	1	BW	PW	17.0	64.00	0.211	3.76	227.07
26	2	3	1	BW	ST	17.0	64.00	0.211	31.75	1917.98
26	2	1	1	BW	TW	17.0	64.00	0.211	7.64	461.40
26	2	4	1	BW	XX	17.0	64.00	0.211	5.51	332.75
2	1	2	1	CO	PW	5.9	20.00	1.756	3.98	240.27
5	2	2	1	CO	PW	11.3	48.00	0.479	3.91	236.24
5	6	2	1	CO	PW	8.8	28.00	0.789	3.96	239.18
5	7	2	1	CO	PW	11.0	44.00	0.505	3.92	236.84
5	8	2	1	CO	PW	5.7	20.00	1.881	3.98	240.30
6	2	2	1	CO	PW	18.7	28.00	0.175	3.87	233.52
6	5	2	1	CO	PW	14.8	32.00	0.279	3.90	235.59
6	7	2	1	CO	PW	18.9	32.00	0.171	3.85	232.31
6	9	2	1	CO	PW	19.2	36.00	0.166	3.82	230.94
6	12	2	1	CO	PW	19.0	32.00	0.169	3.84	232.22
7	1	2	1	CO	PW	8.9	12.00	0.772	3.97	240.08
7	2	2	1	CO	PW	9.9	16.00	0.624	3.97	239.62
7	3	2	1	CO	PW	6.9	20.00	1.284	3.97	240.08
8	2	2	1	CO	PW	14.1	40.00	0.307	3.89	234.89
8	3	2	1	CO	PW	10.0	40.00	0.611	3.94	237.82

CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM TAES PAGE 67
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01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

GRADE-YIELD AND REALIZATION REPORT BY CLASS AND GRADE CODE

CLASS	GRADE	CU.FT.VOLUME	LBS.BIOMASS	SECTION FREQ.	COUNT
YP	TW	8.83	533.24	2.71	6
YP	XX	6.50	392.87	2.71	6
ELM	PW	1.15	69.45	0.29	1
ELM	ST	1.06	64.08	0.29	1
ELM	TW	0.24	14.69	0.29	1
ELM	XX	0.08	4.90	0.29	1
HAC	PW	1.23	74.54	0.31	1
HAC	ST	1.04	63.07	0.31	1
HAC	TW	0.24	14.39	0.31	1
HAC	XX	0.07	4.20	0.31	1
HIC	PW	55.57	3356.39	14.09	22
HIC	ST	74.26	4485.34	14.09	22
HIC	TW	17.32	1045.84	14.09	22
HIC	XX	9.80	592.13	14.09	22
SWD	PW	4.69	283.14	1.18	1
SWD	ST	0.79	47.71	1.18	1
SWD	TW	0.14	8.22	1.18	1
SWD	XX	0.00	0.00	1.18	1
WAO	PW	1.24	75.10	0.32	1
WAO	ST	4.91	296.46	0.32	1
WAO	TW	1.17	70.85	0.32	1
WAO	XX	0.78	47.41	0.32	1
XCO	PW	1.03	62.31	0.27	2
XCO	ST	6.67	402.77	0.27	2
XCO	TW	1.60	96.72	0.27	2
XCO	XX	1.13	68.41	0.27	2
TOTALS		1537.73	92875.12	466.55	832

CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM TAES PAGE 129
ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

GRADE-YIELD AND REALIZATION REPORT BY DBH GROUP

CLASS HIC GRADE ST

DBH GROUP IN.	VOLUME CU. FT.	BIOMASS LBS.	SECT. FREQ.	COUNT
6	0.466	28.119	1.590	1
7	9.164	553.524	6.372	5
8	0.985	59.509	0.931	1
9	2.402	145.075	0.772	1
10	12.082	729.740	1.859	3
12	6.547	395.447	0.424	1
13	3.168	191.368	0.346	1
15	13.949	842.492	0.856	3
17	3.704	223.739	0.211	1
18	3.717	224.520	0.195	1
20	6.637	400.891	0.310	2
23	4.638	280.126	0.119	1
24	6.801	410.788	0.103	1
TOTAL	74.260	4485.336	14.089	22

CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM TAES PAGE 159
ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

NUMBER OF TREES BY DBH GROUP

CLASS HIC

DBH GROUP (IN.)	NUMBER OF TREES	BASAL AREA(SQ.FT.)	PREDICTIONS	COUNT
6	1.59	0.33	25.44	1
7	6.37	1.67	166.58	5
8	0.93	0.33	14.90	1
9	0.77	0.33	21.60	1
10	1.86	1.00	78.00	3
12	0.42	0.33	27.16	1
13	0.35	0.33	11.06	1
15	0.86	1.00	38.88	3
17	0.21	0.33	7.61	1
18	0.20	0.33	7.02	1
20	0.31	0.67	9.95	2
23	0.12	0.33	5.22	1
24	0.10	0.33	6.57	1
TOTAL	14.09	7.33	420.00	22

CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM TAES PAGE 163
ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

NUMBER OF TREES

CLASS	NUMBER OF TREES	BASAL AREA(SQ.FT.)	PREDICTIONS	AVERAGE DBH(IN.)	COUNT
BG	1.77	1.00	62.43	9.84	3
BL	0.42	0.33	8.49	12.00	1
BO	1.40	1.00	25.70	11.05	3
BW	0.21	0.33	13.53	17.00	1
CO	19.08	12.33	527.91	10.05	37
PO	4.08	2.00	117.32	9.36	6
RB	0.24	0.33	4.72	16.10	1
RM	0.30	0.33	15.76	14.20	1
SO	16.94	14.00	654.52	11.71	42
SP	30.61	13.67	1183.84	8.65	41
VP	9.33	5.00	287.29	9.32	15
WO	13.08	7.67	397.41	9.53	23
YP	2.71	2.00	87.40	9.28	6
ELM	0.29	0.33	3.49	14.50	1
HAC	0.31	0.33	3.74	14.00	1
HIC	14.09	7.33	420.00	9.04	22
SWD	1.18	0.33	18.86	7.20	1
WAO	0.32	0.33	15.40	13.80	1
XCO	0.27	0.67	8.21	20.74	2
TOTAL OR AVERAGE	116.65	69.33	3856.03	9.72	208

CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM TAES PAGE 164
ONE STRATUM 1 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

NUMBER OF TREES

STRATA	NUMBER OF TREES	BASAL AREA(SQ.FT.)	PREDICTIONS	AVERAGE DBH(IN.)	COUNT
1	116.65	69.33	3856.02	9.72	208
TOTAL OR AVERAGE	116.65	69.33	3856.02	9.72	208

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CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM          TAES    PAGE 180
ONE STRATUM    1   30    30    80 10.000000  32303  1.50    300
01313 16.0  0.5  8.0   ST  3.0  8.0  3.0  8.0  3.0 11 0           TAES    4
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BOARD-FOOT CONTENT BY DBH GROUP

CLASS HIC GRADE ST

DBH GROUP IN.	BOARD-FOOT CONTENT INTERNATIONAL	SCRIBNER	DOYLE	VOLUME CU.FT.	TREE FREQ.	COUNT
7	39.845	32.767	19.648	8.075	4.926	4
8	4.177	3.179	1.285	0.981	0.931	1
9	13.021	11.224	7.985	2.367	0.772	1
10	69.324	61.141	46.707	11.873	1.859	3
12	38.670	34.483	27.197	6.425	0.424	1
13	18.448	16.363	12.708	3.111	0.346	1
15	82.477	73.576	58.097	13.687	0.856	3
17	21.933	19.576	15.480	3.634	0.211	1
18	22.043	19.684	15.590	3.647	0.195	1
20	39.430	35.236	27.960	6.511	0.310	2
23	27.738	24.849	19.855	4.548	0.119	1
24	40.811	36.604	29.347	6.668	0.103	1
TOTAL	417.917	368.681	281.859	71.527	11.052	20

```
CASE STUDY OF PTMODEL WITH TREES GROUPED IN ONE STRATUM          TAES    PAGE 183
ONE STRATUM    1   30    30    80 10.000000  32303  1.50    300
01313 16.0  0.5  8.0   ST  3.0  8.0  3.0  8.0  3.0 11 0           TAES    4
```

BOARD-FOOT CONTENT SUMMARY

CLASS	GR	BOARD-FOOT CONTENT INTERNATIONAL	SCRIBNER	DOYLE	VOLUME CU.FT.	TREE FREQ.	COUNT
BG	ST	63.400	55.871	42.576	10.883	1.775	3
BL	ST	10.143	8.852	6.550	1.787	0.424	1
BO	ST	38.949	34.639	27.114	6.520	0.577	2
BW	ST	40.087	35.887	28.620	6.586	0.211	1
CO	ST	666.048	590.162	457.034	112.635	13.419	34
PO	ST	79.181	68.629	49.696	14.196	4.081	6
RB	ST	11.398	10.096	7.810	1.930	0.236	1
RM	ST	31.697	28.293	22.376	5.252	0.303	1
SO	ST	1059.902	942.977	738.912	177.220	15.126	41
SP	ST	936.534	824.738	627.204	161.058	27.141	39
VP	ST	329.976	292.930	228.093	55.512	5.755	13
WO	ST	517.164	459.716	359.342	86.680	8.024	20
YP	ST	218.417	195.814	156.792	35.735	0.693	5
ELM	ST	5.846	5.074	3.689	1.045	0.291	1
HAC	ST	5.706	4.934	3.548	1.029	0.312	1
HIC	ST	417.917	368.681	281.859	71.527	11.052	20
WAO	ST	28.985	25.845	20.380	4.816	0.321	1
XCO	ST	39.692	35.495	28.223	6.541	0.271	2
TOTAL		4501.039	3988.632	3089.816	760.949	90.012	192

NORMAL TERMINATION EXIT

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=====================================================================================================
     PPPPPPPP      TTTTTTTTTTTT    MM           MM       OOOO        DDDDDD       EEEEEEE     LL
     PPPPPPPPP     TTTTTTTTTTTT    MMM         MMM     OO    OO      DDDDDDD      EEEEEEE     LL
     PP      PP         TT         MMMM       MMMM    OO      OO     DD     DD    EE          LL
     PP      PP         TT         MM MM     MM MM   OO        OO    DD      DD   EE          LL
     PPPPPPPPP          TT         MM  MM   MM  MM   OO        OO    DD      DD   EEEE        LL
     PPPPPPPP           TT         MM   MM MM   MM   OO        OO    DD      DD   EEEE        LL
     PP                 TT         MM    MMM    MM   OO        OO    DD      DD   EE          LL
     PP                 TT         MM    MMM    MM    OO      OO     DD     DDD   EE          LL
     PP                 TT         MM           MM     OO    OO      DDDDDDDD     EEEEEEEE    LLLLLLLLL
     PP                 TT         MM           MM       OOOO        DDDDDDD      EEEEEEEE    LLLLLLLLL
```

A COMPUTER PROCESSING SYSTEM FOR POINT-MODEL DEPENDENT SAMPLING

VERSION 1.2
1 JULY 1991

WRITTEN BY : JOHN C. RENNIE
DEPARTMENT OF FORESTRY, WILDLIFE AND FISHERIES
THE UNIVERSITY OF TENNESSEE
KNOXVILLE, TENNESSEE 37901-1071

OPTIONS SPECIFIED FOR CURRENT RUN

JOB NAME : PTMODEL WITH TREES GROUPED IN FOUR STRATA AND ADDED 1ST STAGE TR,JOB IDENTIFIER: TAES,SHORT IDENTIFIER: PTMODEL

NUMBER OF STRATA : 4   NUMBER OF SAMPLE PLOTS, LINES OR POINTS :   30   LARGEST PLOT, LINE OR POINT NUMBER RECORDED :   30

MAXIMUM ESTIMATED TREE HEIGHT :   80 FT.   SAMPLE EXPANSION FACTOR : 10.000000   SYSTEM OF UNITS USED : ENGLISH

TYPE OF SAMPLES USED : HORIZONTAL POINT SAMPLES TYPE OF VARIANCE ESTIMATE : BOOTSTRAP

TYPE OF PRINTED INDIVIDUAL TREE DETAIL OUTPUT : TREE AND SEGMENT DETAIL   DETAIL STORED : NONE

EXPONENT FOR WEIGHTED REGRESSION FOR VOLUME : 1.50   NUMBER OF BOOTSTRAP SAMPLES REQUESTED :   300

MASS PER UNIT VOLUME BY STRATUM (LBS./CU.FT.):   58.   65.   60.   59.

BARK DEDUCTED : BY TREE STAND TABLES REQUESTED : YES   STOCK TABLES REQUESTED : BD.FT. & CU.FT.

GRADE-YIELD (VOLUME & BIOMASS) AND REALIZATION REPORTS REQUESTED : BY CLASS AND GRADE & BY SECTION

TYPE OF PRINTED BOARD FOOT REPORTS:LOG AND TREE REPORTS REQUESTED   DETAIL STORED ON UNIT MPUB :BD.FT. LOG & TREE DETAIL

LOG SPECIFICATIONS IN FEET : MAXIMUM SCALING LENGTH : 16.0 TRIM ALLOWANCE :   0.5 MINIMUM LENGTH :   8.0 PRODUCT CODE : ST

TOP DOB FOR INTERPOLATION (INCHES) :   3.0 MID DOB FOR INTERPOLATION (INCHES) :   8.0

TOP DIB FOR INTERPOLATION (INCHES) :   3.0 MID DIB FOR INTERPOLATION (INCHES) :   8.0

MINIMUM TOP DIAMETER FOR PROJECTION (INCHES) :   3.0, PERCENTAGE DEDUCTION APPLIED TO : INTERNATIONAL 1/4

LOGICAL UNIT ASSIGNED TO DATA INPUT :   5, TO PRINTER :   6 ,TO DATA OUTPUT MPU, MPUB, MPUC :   1   2   3

AND FOR INTERMEDIATE STORAGE JW, JX, ITBF, ITBR, AND ITST :   4   8   9   10   11

PTMODEL 4 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

REGRESSION COEFFICIENTS BY STRATUM AND GRADE CALCULATED FROM SECOND-STAGE TREES

COEFFICIENT SET NUMBER	STRATUM NUMBER	GRADE CODE	COEFFICIENTS FOR WEIGHTED REGRESSION A	B	OUTPUT PRODUCT	NUMBER OF TREES
1	1	TW	0.21487921	0.00039711	VOLUME	9
2	1	TW	12.52741530	0.02315161	BIOMASS	9
3	1	PW	4.08930779	-0.00042613	VOLUME	9
4	1	PW	238.40678400	-0.02484333	BIOMASS	9
5	1	ST	-1.62979221	0.00270553	VOLUME	9
6	1	ST	-95.01686100	0.15773267	BIOMASS	9
7	1	ST	-10.48281100	0.01570862	BOARD FT.(INT.)	9
8	1	ST	-9.53908920	0.01357152	BOARD FT.(SCRB.)	9
9	1	ST	-7.67494011	0.00962964	BOARD FT.(DOYLE)	9
10	1	ST	-1.62951946	0.00274361	VOLUME (CU.FT.)	9
11	1	XX	0.00000000	0.00000000	VOLUME	9
12	1	XX	0.00000000	0.00000000	BIOMASS	9
13	2	TW	-1.07262707	0.00057950	VOLUME	9
14	2	TW	-69.18438720	0.03737750	BIOMASS	9
15	2	PW	3.91768265	0.00020846	VOLUME	9
16	2	PW	252.69035300	0.01344573	BIOMASS	9
17	2	ST	-1.40050697	0.00160610	VOLUME	9
18	2	ST	-90.33348080	0.10359389	BIOMASS	9
19	2	ST	-10.76561160	0.00974269	BOARD FT.(INT.)	9
20	2	ST	-11.15962120	0.00885107	BOARD FT.(SCRB.)	9
21	2	ST	-11.99446490	0.00724945	BOARD FT.(DOYLE)	9
22	2	ST	-1.20159435	0.00148947	VOLUME (CU.FT.)	9
23	2	XX	-0.19501185	0.00008168	VOLUME	9
24	2	XX	-12.57826900	0.00526850	BIOMASS	9
25	3	TW	-0.83700126	0.00031527	VOLUME	6
26	3	TW	-49.80166630	0.01875869	BIOMASS	6
27	3	PW	14.51116090	-0.00035321	VOLUME	6
28	3	PW	863.41406200	-0.02101596	BIOMASS	6
29	3	ST	-6.44010162	0.00183408	VOLUME	6
30	3	ST	-383.18627900	0.10912734	BIOMASS	6
31	3	ST	-42.98358150	0.01161989	BOARD FT.(INT.)	6
32	3	ST	-40.14108280	0.01069123	BOARD FT.(SCRB.)	6
33	3	ST	-36.84234620	0.00931878	BOARD FT.(DOYLE)	6
34	3	ST	-6.59570980	0.00183361	VOLUME (CU.FT.)	6
35	3	XX	-5.32151985	0.00084754	VOLUME	6
36	3	XX	-316.62963900	0.05042873	BIOMASS	6
37	4	TW	-0.24737263	0.00052696	VOLUME	9
38	4	TW	-14.66906070	0.03124867	BIOMASS	9
39	4	PW	4.24910069	-0.00015726	VOLUME	9
40	4	PW	251.97160300	-0.00932552	BIOMASS	9
41	4	ST	-0.83273983	0.00174488	VOLUME	9
42	4	ST	-49.38250730	0.10347188	BIOMASS	9
43	4	ST	-11.44283490	0.01085053	BOARD FT.(INT.)	9
44	4	ST	-11.69338130	0.00981018	BOARD FT.(SCRB.)	9
45	4	ST	-11.93133740	0.00778325	BOARD FT.(DOYLE)	9
46	4	ST	-0.64568937	0.00171711	VOLUME (CU.FT.)	9

PTMODEL 4 30 30 80 10.000000 32303 1.50 300
01313 16.0 0.5 8.0 ST 3.0 8.0 3.0 8.0 3.0 11 0 TAES 4

REGRESSION COEFFICIENTS BY STRATUM AND GRADE CALCULATED FROM SECOND-STAGE TREES

COEFFICIENT SET NUMBER	STRATUM NUMBER	GRADE CODE	COEFFICIENTS FOR WEIGHTED REGRESSION A	B	OUTPUT PRODUCT	NUMBER OF TREES
47	4	XX	-0.80899793	0.00029740	VOLUME	9
48	4	XX	-47.97358700	0.01763584	BIOMASS	9

```
PTMODEL        4    30     30     80 10.000000  32303  1.50    300
01313 16.0  0.5  8.0   ST  3.0  8.0  3.0  8.0  3.0 11 0            TAES   4
```

BOOTSTRAP ESTIMATE OF VARIANCE

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================================================================================
ESTIMATE OF THE MEAN----------------------             1631.3816
STANDARD DEVIATION------------------------              144.6052
STD.DEV. AS A PERCENT OF THE MEAN---------                8.8640
NUMBER OF BOOTSTRAP SAMPLES-----------------------           300
NUMBER OF SECOND-STAGE TREES----------------------            33
NUMBER OF SAMPLE PLOTS, LINES OR POINTS ----------            30
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PPPPPPPP      TTTTTTTTTTTT     MM            MM       OOOO        DDDDDD      EEEEEEE     LL
PPPPPPPPP     TTTTTTTTTTTT     MMM          MMM     OO    OO      DDDDDDD     EEEEEEE     LL
PP      PP         TT          MMMM        MMMM    OO      OO     DD    DD    EE          LL
PP      PP         TT          MM MM      MM MM   OO        OO    DD     DD   EE          LL
PPPPPPPPP          TT          MM  MM    MM  MM   OO        OO    DD     DD   EEEE        LL
PPPPPPPP           TT          MM   MM MM    MM   OO        OO    DD     DD   EEEE        LL
PP                 TT          MM    MMM     MM   OO        OO    DD     DD   EE          LL
PP                 TT          MM    MMM     MM    OO      OO     DD    DDD   EE          LL
PP                 TT          MM            MM     OO    OO      DDDDDDDD    EEEEEEEE    LLLLLLLLL
PP                 TT          MM            MM       OOOO        DDDDDDD     EEEEEEEE    LLLLLLLLL
```

A COMPUTER PROCESSING SYSTEM FOR POINT-MODEL DEPENDENT SAMPLING

VERSION 1.2
1 JULY 1991

WRITTEN BY : JOHN C. RENNIE
DEPARTMENT OF FORESTRY, WILDLIFE AND FISHERIES
THE UNIVERSITY OF TENNESSEE
KNOXVILLE, TENNESSEE 37901-1071

OPTIONS SPECIFIED FOR CURRENT RUN

JOB NAME : CASE STUDY OF PTMODEL WITH TREES GROUPED IN FOUR STRATA ,JOB IDENTIFIER: TAES,SHORT IDENTIFIER: PTMODEL

NUMBER OF STRATA : 4 NUMBER OF SAMPLE PLOTS, LINES OR POINTS : 30 LARGEST PLOT, LINE OR POINT NUMBER RECORDED : 30

MAXIMUM ESTIMATED TREE HEIGHT : 80 FT. SAMPLE EXPANSION FACTOR : 10.000000 SYSTEM OF UNITS USED : ENGLISH

TYPE OF SAMPLES USED : HORIZONTAL POINT SAMPLES TYPE OF VARIANCE ESTIMATE : BOOTSTRAP

TYPE OF PRINTED INDIVIDUAL TREE DETAIL OUTPUT : TREE AND SEGMENT DETAIL DETAIL STORED : NONE

EXPONENT FOR WEIGHTED REGRESSION FOR VOLUME : 1.50 NUMBER OF BOOTSTRAP SAMPLES REQUESTED : 300

MASS PER UNIT VOLUME BY STRATUM (LBS./CU.FT.): 58. 65. 60. 59.

BARK DEDUCTED : BY TREE STAND TABLES REQUESTED : YES STOCK TABLES REQUESTED : BD.FT. & CU.FT.

GRADE-YIELD (VOLUME & BIOMASS) AND REALIZATION REPORTS REQUESTED : BY CLASS AND GRADE & BY SECTION

TYPE OF PRINTED BOARD FOOT REPORTS:LOG AND TREE REPORTS REQUESTED DETAIL STORED ON UNIT MPUB :BD.FT. LOG & TREE DETAIL

LOG SPECIFICATIONS IN FEET : MAXIMUM SCALING LENGTH : 16.0 TRIM ALLOWANCE : 0.5 MINIMUM LENGTH : 8.0 PRODUCT CODE : ST

TOP DOB FOR INTERPOLATION (INCHES) : 3.0 MID DOB FOR INTERPOLATION (INCHES) : 8.0

TOP DIB FOR INTERPOLATION (INCHES) : 3.0 MID DIB FOR INTERPOLATION (INCHES) : 8.0

MINIMUM TOP DIAMETER FOR PROJECTION (INCHES) : 3.0, PERCENTAGE DEDUCTION APPLIED TO : INTERNATIONAL 1/4

LOGICAL UNIT ASSIGNED TO DATA INPUT : 5, TO PRINTER : 6 ,TO DATA OUTPUT MPU, MPUB, MPUC : 1 2 3

AND FOR INTERMEDIATE STORAGE JW, JX, ITBF, ITBR, AND ITST : 4 8 9 10 11

CASE STUDY OF PTMODEL WITH TREES GROUPED IN FOUR STRATA   TAES   PAGE 17
PTMODEL   4   30   30   80 10.000000 32303 1.50   300
01313 16.0 0.5 8.0   ST 3.0 8.0 3.0 8.0 3.0 11 0   TAES   4

REGRESSION COEFFICIENTS BY STRATUM AND GRADE CALCULATED FROM SECOND-STAGE TREES

COEFFICIENT SET NUMBER	STRATUM NUMBER	GRADE CODE	COEFFICIENTS FOR WEIGHTED REGRESSION A	B	OUTPUT PRODUCT	NUMBER OF TREES
1	1	TW	-0.24456948	0.00042704	VOLUME	3
2	1	TW	-14.25839520	0.02489624	BIOMASS	3
3	1	PW	4.56281281	-0.00057518	VOLUME	3
4	1	PW	266.01196300	-0.03353298	BIOMASS	3
5	1	ST	-1.46315289	0.00254817	VOLUME	3
6	1	ST	-85.30177310	0.14855832	BIOMASS	3
7	1	ST	-7.92395115	0.01384081	BOARD FT.(INT.)	3
8	1	ST	-6.52196026	0.01139718	BOARD FT.(SCRB.)	3
9	1	ST	-3.92794037	0.00687325	BOARD FT.(DOYLE)	3
10	1	ST	-1.44766140	0.00252649	VOLUME (CU.FT.)	3
11	1	XX	0.00000000	0.00000000	VOLUME	3
12	1	XX	0.00000000	0.00000000	BIOMASS	3
13	2	TW	-1.07262707	0.00057950	VOLUME	9
14	2	TW	-69.18438720	0.03737750	BIOMASS	9
15	2	PW	3.91768265	0.00020846	VOLUME	9
16	2	PW	252.69035300	0.01344573	BIOMASS	9
17	2	ST	-1.40050697	0.00160610	VOLUME	9
18	2	ST	-90.33348080	0.10359389	BIOMASS	9
19	2	ST	-10.76561160	0.00974269	BOARD FT.(INT.)	9
20	2	ST	-11.15962120	0.00885107	BOARD FT.(SCRB.)	9
21	2	ST	-11.99446490	0.00724945	BOARD FT.(DOYLE)	9
22	2	ST	-1.20159435	0.00148947	VOLUME (CU.FT.)	9
23	2	XX	-0.19501185	0.00008168	VOLUME	9
24	2	XX	-12.57826900	0.00526850	BIOMASS	9
25	3	TW	4.41655159	0.00014276	VOLUME	3
26	3	TW	262.78491200	0.00849422	BIOMASS	3
27	3	PW	0.00000000	0.00000000	VOLUME	3
28	3	PW	0.00000000	0.00000000	BIOMASS	3
29	3	ST	50.99694820	0.00052104	VOLUME	3
30	3	ST	3034.32544000	0.03100143	BIOMASS	3
31	3	ST	303.68847700	0.00389423	BOARD FT.(INT.)	3
32	3	ST	274.86059600	0.00373075	BOARD FT.(SCRB.)	3
33	3	ST	219.34480300	0.00382606	BOARD FT.(DOYLE)	3
34	3	ST	55.88024900	0.00044561	VOLUME (CU.FT.)	3
35	3	XX	-60.40498350	0.00206193	VOLUME	3
36	3	XX	-3594.09839000	0.12268454	BIOMASS	3
37	4	TW	-0.72450721	0.00074009	VOLUME	3
38	4	TW	-42.96322630	0.04388706	BIOMASS	3
39	4	PW	4.78084660	-0.00078818	VOLUME	3
40	4	PW	283.50390600	-0.04673898	BIOMASS	3
41	4	ST	-5.26769543	0.00399176	VOLUME	3
42	4	ST	-312.37548800	0.23671168	BIOMASS	3
43	4	ST	-35.81413270	0.02269614	BOARD FT.(INT.)	3
44	4	ST	-31.97972110	0.01970155	BOARD FT.(SCRB.)	3
45	4	ST	-23.73207090	0.01371678	BOARD FT.(DOYLE)	3
46	4	ST	-6.03028107	0.00432823	VOLUME (CU.FT.)	3

CASE STUDY OF PTMODEL WITH TREES GROUPED IN FOUR STRATA   TAES   PAGE 18
PTMODEL   4   30   30   80 10.000000 32303 1.50   300
01313 16.0 0.5 8.0   ST 3.0 8.0 3.0 8.0 3.0 11 0   TAES   4

REGRESSION COEFFICIENTS BY STRATUM AND GRADE CALCULATED FROM SECOND-STAGE TREES

COEFFICIENT SET NUMBER	STRATUM NUMBER	GRADE CODE	COEFFICIENTS FOR WEIGHTED REGRESSION A	B	OUTPUT PRODUCT	NUMBER OF TREES
47	4	XX	0.00000000	0.00000000	VOLUME	3
48	4	XX	0.00000000	0.00000000	BIOMASS	3

```
PTMODEL        4   30     30     80 10.000000  32303  1.50    300
01313 16.0  0.5  8.0    ST  3.0  8.0  3.0  8.0  3.0 11 0             TAES   4
```

BOOTSTRAP ESTIMATE OF VARIANCE

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==============================================================================
ESTIMATE OF THE MEAN----------------------          1820.5269
STANDARD DEVIATION------------------------           577.3384
STD.DEV. AS A PERCENT OF THE MEAN---------            31.7127
NUMBER OF BOOTSTRAP SAMPLES-----------------------        300
NUMBER OF SECOND-STAGE TREES----------------------         18
NUMBER OF SAMPLE PLOTS, LINES OR POINTS ----------         30
==============================================================================
```

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
KNOXVILLE, TENNESSEE 37996-4500

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